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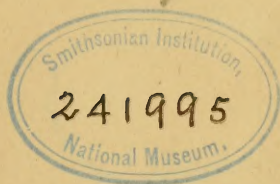




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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 7.

SPRAYING FRUITS

FOR

INSECT PESTS AND FUNGOUS DISEASES,

WITH

A SPECIAL CONSIDERATION OF THE SUBJECT IN
ITS RELATION TO THE PUBLIC HEALTH.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

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FARMERS' BULLETINS.

The bulletins of this series may be obtained by applying to the Secretary of Agriculture, Washington, D. C. The following have been previously issued:

Farmers' Bulletin No. 1. The What and Why of Agricultural Experiment Stations. (A brief explanation of the object, origin, and development of the stations, their work in Europe and in the United States, and the operations of the Office of Experiment Stations of the Department of Agriculture.) Prepared by the Office of Experiment Stations; pp. 16. Issued June, 1889.

Farmers' Bulletin No. 2. The Work of the Agricultural Experiment Stations; (Illustrations of Station Work in the following lines: better cows for the dairy; fibrin in milk; bacteria in milk, cream, and butter; silos and silage; alfalfa; and field experiments with fertilizers.) Prepared by the Office of Experiment Stations; pp. 16. Issued June, 1889.

Farmers' Bulletin No. 3. The Culture of the Sugar Beet. (Treats of the climatic conditions, soil, fertilizers, and cultivation required by the sugar beet, cost of growing, time to harvest, and method of soiling; describes briefly the process of beet-sugar manufacture, and gives statistics of sugar production and consumption.) By H. W. Wiley, chemist of the Department of Agriculture; pp. 24. Issued March, 1891.

Farmers' Bulletin No. 4. Fungous Diseases of the Grape and their Treatment. (Describes downy mildew, powdery mildew, black rot, and anthracnose of grapes and gives instructions for their treatment and estimated cost of remedies.) By B. T. Galloway, Chief of the Division of Vegetable Pathology; pp. 12. Issued March, 1891.

Farmers' Bulletin No. 5. Treatment of Smuts of Oats and Wheat. (Describes the smuts of wheat, oats, and barley, the damage they cause, and the various methods of treatment which have been found useful for their prevention.) Prepared by the Division of Vegetable Pathology; pp. 8. Issued February, 1892.

Farmers' Bulletin No. 6. Tobacco: Instructions for its cultivation and curing. Prepared by John M. Estes, special agent; pp. 8. Issued February, 1892.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE ASSISTANT SECRETARY,
Washington, D. C., March 10, 1892.

SIR: I have the honor to transmit herewith for publication a bulletin prepared in accordance with my direction by the Divisions of Entomology and Vegetable Pathology, to be included in the series of farmers' bulletins of this Department, treating of the practice, methods, and effects of spraying fruit trees for insect pests and fungous diseases. This practice has been widely extended during the past few years, largely upon the lines laid down by this Department as the result of careful and extended experiments. The fact that the compounds as generally used are slightly poisonous in their character has led some persons to express apprehension lest their application should injure the fruit for consumption. This apprehension has been shown over and over again to be ill founded, frequent experiments under all possible conditions having shown that no spraying as prescribed by the Department experts has ever resulted in the slightest deleterious effects upon the fruit subjected to it. While this bulletin presents the subject of spraying in the most practical manner for the information of the orchardist and fruit-grower, it is mainly intended for the information and satisfaction of the consumer, by showing him exactly the character of the spraying recommended, and the utter impossibility of evil consequences to him.

The publication of this bulletin in this brief and practical form is rendered especially necessary and timely by the fact that persons antagonizing, from interested motives, the importation of American fruit into Great Britain have indulged in the frequent assertion that spraying as practiced in this country must necessarily have deleterious effects upon the fruit and injure it for consumption. It is believed that the present bulletin, and the simple facts therein arrayed, will serve a useful purpose in thoroughly exploding the baseless charges which have been leveled on this score against American fruits in Great Britain and other countries.

Respectfully,

EDWIN WILLITS,
Assistant Secretary.

Hon. J. M. RUSK,
Secretary.

SPRAYING FOR INSECT PESTS AND FUNGOUS DISEASES.

SPRAYING FOR INSECT PESTS.

The distribution of insecticide mixtures in the form of spray was first begun in this country on a large scale during the early spread of the Colorado potato-beetle in the Western States. Paris green was first used in 1869 both as a dry mixture diluted with flour, ashes, plaster, or slacked lime, and in liquid suspension in water. Spray machines soon came into use, and this method of application of insect-destroying mixtures was speedily extended to other insect pests. In 1878 poisoned spray was first used against the codling-moth, and the Entomologist of the Department had previously recommended this remedy for the cotton-worm and several other leaf-eating insects. During the progress of the investigation of the cotton-worm many spraying machines were developed, and from that time to the present the development of methods and machinery has been rapid, until at the present time the best remedies against perhaps the majority of our principal insect pests comprehend the application of an insecticide spray at one time or another.

INSECTICIDES USED IN THE FORM OF A SPRAY.

Kerosene emulsion.—This insecticide acts by contact and is applicable to all nonmasticating insects (sucking insects, such as the true bugs and especially plant-lice and scale-insects) and also to many of the mandibulate or masticating insects, such as the apple worm or plum curculio, when the use of arsenites is not advisable. Kerosene emulsion may be made by means of various emulsifying agents, but the most satisfactory substances—and those most available to the average farmer and fruit-grower—are milk and soapsuds. In each of these cases the amount of emulsifying agent should be one-half the quantity of kerosene.

One of the most satisfactory formulas is as follows:

	Per cent.
Kerosene	gallons.. 2 67
Common soap or whale-oil soap	pounds.. $\frac{1}{2}$ } 33
Water	gallons.. 1 }

Heat the solution of soap and add it boiling hot to the kerosene. Churn the mixture by means of a force pump and spray nozzle for five or ten minutes. The emulsion, if perfect, forms a cream which thickens upon cooling and should adhere without oiliness to the surface of glass. If the water from the soil is hard or has a large percentage of lime add a little lye or bicarbonate of soda, or else use rain-water. For use against scale-insects dilute one part of the emulsion with nine parts of cold water. For most other insects dilute one part of the emulsion with fifteen parts of water. For soft insects like plant-lice the dilution may be carried to from 20 to 25 parts of water.

The milk emulsion is produced by the same methods as the above.

The resin washes.—These insecticides act by contact, and also, in the case of scale-insects, by forming an impervious coating which effectually smothers the insects treated. These resin washes vary in efficacy according to the insect treated. Experience has shown that the best formula for the red scale (*Aspidiotus aurantii* Maskell) and its yellow variety (*A. citrinus* Coquillett) is as follows:

Resin.....	pounds..	18
Caustic soda (70 per cent strength).....	do.....	5
Fish oil.....	pints..	2½
Water to make.....	gallons..	100

The necessary ingredients are placed in a kettle and a sufficient quantity of cold water added to cover them. They are then boiled until dissolved, being occasionally stirred in the meantime, and after the materials are dissolved the boiling should be continued for about an hour, and a considerable degree of heat should be employed so as to keep the preparation in a brisk state of ebullition, cold water being added in small quantities whenever there are indications of the preparation boiling over. Too much cold water, however, should not be added at one time, or the boiling process will be arrested and thereby delayed, but by a little practice the operator will learn how much water to add so as to keep the preparation boiling actively. Stirring the preparation is quite unnecessary during this stage of the work. When boiled sufficiently it will assimilate perfectly with water, and should then be diluted with the proper quantity of cold water, adding it slowly at first and stirring occasionally during the process. The undiluted preparation is pale yellowish in color, but by the addition of water it becomes a very dark brown. Before being sprayed on the trees it should be strained through a fine wire sieve, or through a piece of Swiss muslin, and this is usually accomplished, when pouring the liquid into the spraying tank, by means of a strainer placed over the opening through which the preparation is introduced into the tank.

The preparing of this compound will be greatly accelerated if the resin and caustic soda are first pulverized before being placed in the boiler, but this is quite a difficult task to perform. Both of these substances are put up in large cakes for the wholesale trade, the resin being in wooden barrels, each barrel containing a single cake, weighing

about 375 pounds, while the caustic soda is put up in iron drums containing a single cake each, weighing about 800 pounds. The soda is the most difficult to dissolve, but this could doubtless be obviated by first dissolving it in cold water and then using the solution as required. This insecticide may be applied at any time during the growing season.

A stronger wash is required for the San José scale (*Aspidiotus perniciosus* Comstock), and the following formula gives the best results:

Resin	pounds..	30
Caustic soda (70 per cent).....	do....	9
Fish oil	pints..	4½
Water enough to make	gallons..	100

Place all the ingredients in a kettle and cover with water to a depth of 4 or 5 inches; boil briskly for about two hours, or until the compound can be perfectly dissolved with water. When this stage is reached the kettle should be filled up with water, care being taken not to chill the wash by adding large quantities of cold water at once. It may be thus diluted to about 40 gallons, the additional water being added from time to time as it is used.

This preparation should only be applied during winter or during the dormant period; applied in the growing season, it will cause the loss of foliage and fruit.

In the application of both these washes a very fine spray is not essential, as the object is not simply to wet the tree, but to thoroughly coat it over with the compound, and this can be best accomplished by the use of a rather coarse spray, which can be thrown upon the tree with considerable force.

THE ARSENITES: LONDON PURPLE, PARIS GREEN, AND WHITE ARSENIC.

These poisons are of the greatest service against all masticating insects, as larvæ and beetles, and they furnish the most satisfactory means of controlling most leaf-feeders, and the best wholesale remedy against the codling-moth. Caution must be used in applying them, on account of the liability of burning or scalding the foliage.

The poisons should be thoroughly mixed with water at the rate of from 1 pound to 100 to 250 gallons of water, and applied with a force pump and spray nozzle. In preparing the wash, it will be best to first mix the poison with a small quantity of water, making a thick batter, and then dilute the latter and add to the reservoir or spray tank, mixing the whole thoroughly. When freshly mixed, either London purple or Paris green may be applied to apple, plum, and other fruit trees, except the peach, at the rate of 1 pound to 150 to 200 gallons, the latter amount being recommended for the plum, which is somewhat more susceptible to scalding than the apple. White arsenic does little, if any, injury at the rate of 1 pound to 50 gallons of water when freshly mixed. As shown by Mr. Gillette, however, when allowed to remain for some time (two weeks or more) in water, the white arsenic

acts with wonderful energy, scalding when used at the rate of 1 pound to 100 gallons from 10 to 90 per cent of the foliage; the action of the other arsenites remains practically the same, with perhaps a slight increase in the case of London purple.

With the peach these poisons, when applied alone, even at the rate of 1 pound to 300 or more gallons of water, are injurious in their action, causing the loss of much of the foliage.

By the addition of a little lime to the mixture, London purple and Paris green may be safely applied, at the rate of 1 pound to 125 to 150 gallons of water, to the peach or the tenderest foliage, or in much greater strength to strong foliage, such as that of the apple or most shade trees.

Whenever, therefore, the application is made to tender foliage or when the treating with a strong mixture is desirable, lime water, milky, but not heavy enough to close the nozzle, should be added at the rate of about 2 gallons to 100 gallons of the poison.

With the apple, in spraying for the codling-moth, at least two applications should be made, the first after the falling of the blossoms or when the apples are about the size of peas, and the second a week or ten days later. The first brood of the codling moth lays its eggs in the flower end of the young apple, and the worms upon hatching gnaw their way into the interior of the apple, and on sprayed trees get poisoned in so doing, an infinitesimal amount being sufficient to destroy so minute a worm. The second spraying is for the purpose of destroying larvæ hatching from eggs which may be laid after the first spraying, as the arsenic is gradually washed off by rains.

For the plum curculio on the plum, cherry, peach, etc., two or three applications should be made during the latter part of May and the first half of June. The poison in this case is applied for the purpose of destroying the adult curculios which hibernate and gnaw into the young growth of the trees and even into the hard young fruit before laying their eggs. The eggs are pushed under the skin so that the larvæ are not ordinarily affected by the poisoning.

In the case of most leaf-feeding insects one should spray on the first indication of their presence.

Caution necessary in the use of these insecticides.—The relative susceptibility of apple, plum, and peach has just been indicated under the head of arsenical poisons, and these remarks apply equally well to the use of the kerosene emulsions. In the case of other plants thorough experiments are still necessary, and all insecticides should be used in comparatively high dilution. Tender-leaved plants, such as melons and cucumbers, are more readily injured; while plants with firmer and smooth leaves, like the orange, are least affected. Annual plants, such as cabbages and other garden vegetables, are more susceptible than perennials; but in the case of root crops, such as beets, turnips, radishes, and potatoes, there is not the same need of caution as to damage to foliage. Damage

to foliage is not shown at once, and in case of rain following an application another application should not be made for several days. Fruit trees should not be sprayed with arsenical poisons while in blossom, as there is no advantage in doing so, and honeybees are reported to be at times killed by working in the sprayed blossoms.

SPRAYING FROM THE HYGIENIC STANDPOINT.

The only insecticide sprays which are at all dangerous to use are the arsenic compounds, and even here the danger is greatly exaggerated by those not conversant with the facts. Paris green and London purple have for many years been extensively used in this country as insecticides and a case of fatal poisoning from their use as such has never been substantiated. The only danger lies in having the poison about a farm or plantation in bulk. In the early days of the use of Paris green against the Colorado potato-beetle a great deal of opposition was developed on account of the supposed danger, and only recently the sale of American apples in England has received a set-back owing to the supposed danger of arsenic poisoning from their consumption. The question as to whether arsenic may be absorbed by the growing plant in any degree was long ago settled in the negative by the best chemists in the country. Dr. William McMurtrie, formerly chemist of this Department, in 1878 showed that even where Paris green was applied to the soil in such quantities as to cause the wilting or death of the plants, the most rigorous chemical analysis could detect no arsenic in the composition of the plants themselves. Other experiments in a similar direction by Prof. R. C. Kedzie, of the Michigan Agricultural College, confirmed these conclusions. It is safe, then, to assume that the only way in which fruit or vegetables can convey the poison to the consumer will be through the very minute quantity of arsenic left upon the edible part of the plant. Against the possibility of such an effect the following facts may be given:

(1) It would seem at first glance that the use of an arsenical poison upon a plant like the cabbage would be very unsafe to recommend, yet Paris green and London purple are used upon this crop to kill the several species of leaf-eating worms which are so destructive to it, and an absolute absence of all danger where the application has been properly made has been recently shown by Prof. Gillette, of the Agricultural Experiment Station of Colorado, by the following *reductio ad absurdum*:

* * * Where the green is dusted from a bag in the proportion of 1 ounce of the poison to 100 ounces of flour and just enough applied to each head to make a slight show of dust on the leaves, say, for twenty-eight heads of cabbage, 1 ounce of mixture, the worms will all be killed in the course of two or three days, while the average amount of poison on each head will be about one-seventh of a grain. Fully one-half of the powder will fall on the outside leaves and on the ground, and thus an individual will have to eat about twenty-eight heads of cabbage in order to consume a poisonous dose of arsenic, even if the balance of the poison remained after cooking.

(2) In case of spraying apple orchards for the codling-moth there is scarcely a possibility of injury to the consumer of the fruit. A mathematical computation will quickly show that where the poison is used in the proportion of 1 pound to 200 gallons of water (the customary proportion) the arsenic will be so distributed through the water that it will be impossible for a sufficient quantity to collect upon any given apple to have the slightest injurious effect upon the consumer. In fact, such a computation will indicate beyond all peradventure that it will be necessary for an individual to consume several barrels of apples at a single meal in order to absorb a fatal dose even should this enormous meal be eaten soon after the spraying and should the consumer eat the entire fruit.

(3) As a matter of fact careful microscopic examinations have been made of the fruit and foliage of sprayed trees at various intervals after spraying which indicate that after the water has evaporated the poison soon entirely disappears either through being blown off by the wind or washed off by rains, so that after fifteen days hardly the minutest trace can be discovered.

(4) In the line of actual experiment as indicating the very finely divided state of the poison and the extremely small quantity which is used to each tree Prof. A. J. Cook, of the Michigan Agricultural College, has conducted some striking experiments. A thick paper was placed under an apple tree which was thoroughly sprayed on a windy day so that the dripping was rather excessive. After the dripping had ceased, the paper (covering a space of 72 square feet) was analyzed and four-tenths of a grain of arsenic was found. Another tree was thoroughly sprayed and subsequently the grass and clover beneath it was carefully cut and fed to a horse without the slightest sign of injury.

The whole matter was well summed up by Professor Riley in a recent lecture before the Lowell Institute, in Boston, in the following words:

The latest sensational report of this kind was the rumor, emanating from London, within the last week, that American apples were being rejected for fear that their use was unsafe. If we consider for a moment how minute is the quantity of arsenic that can, under the most favorable circumstances, remain in the calyx of an apple, we shall see at once how absurd this fear is; for, even if the poison that originally killed the worm remained intact, one would have to eat many barrels of apples at a meal to get a sufficient quantity to poison a human being. Moreover, much of the poison is washed off by rain, and some of it is thrown off by natural growth of the apple, so that there is, as a rule, nothing left of the poison in the garnered fruit. Add to this the further fact that few people eat apples raw without casting away the calyx and stem ends, the only parts where any poison could, under the most favorable circumstances, remain, and that these parts are always cut away in cooking, and we see how utterly groundless are any fears of injury and how useless any prohibitive measures against American apples on this score.

SPRAYING FOR FUNGOUS DISEASES OF THE APPLE, PEAR, AND OTHER FRUITS.

Probably in no other country of the world is spraying for fungous diseases of fruits practiced to the same extent as in the United States. Five years ago practically nothing was known of this subject; in fact, the number actively engaged in spraying their trees, vines, etc., for such diseases as apple scab, black-rot, downy mildew, and other diseases of the grape did not exceed half a hundred, all told. Now, as a fair estimate, probably no less than 50,000 fruit-growers are engaged in this work. From the Atlantic to the Pacific and from the Great Lakes to the Gulf the methods recommended by the Department are practiced every year. Canada has also adopted many of the suggestions made by us, and even now Australia is actively engaged in experiments in the treatment of apple, pear, peach, and other diseases, in accordance with suggestions originating with this Department.

DOES IT PAY TO SPRAY?

This question is in large part answered by the facts already given. No work that did not carry merit with it could have had such a phenomenal growth. To give a more direct answer, however, it may be stated that last season two hundred and fifty grape-growers in different parts of the country made a series of observations with a view of obtaining some definite information as to the value in dollars and cents of the recommendations made by the Department in the treatment of grape diseases. The facts reported by these men show conclusively that the actual profit to them over all expenses resulting from the treatment of black-rot and downy mildew was in round numbers \$37,000. Thirteen thousand dollars of this sum was reported from the State of New York alone.

Other examples equally as striking could be given, but this is sufficient for our purpose. Of course, every one is not successful, but where failure is reported it is usually easy to locate and remedy the trouble.

FUNGICIDES OR REMEDIES USED IN SPRAYING.

Numerous preparations have been recommended and used for this work. For all practical purposes, however, there are but four which properly may be called remedies. They are (1) Bordeaux mixture, (2) ammoniacal solution of copper carbonate, (3) eau céleste, and (4) modi-

fied eau céleste. The latest experiments indicate that the best results will follow the use of these preparations when made as follows:

1.—BORDEAUX MIXTURE.

In a barrel that will hold 45 gallons dissolve 6 pounds of copper sulphate, using 8 or 10 gallons of water or as much as may be necessary for the purpose. In a tub or half barrel slake 4 pounds of *fresh* lime. When completely slaked add enough water to make a creamy whitewash. Pour this slowly into the barrel containing the copper-sulphate solution, using a coarse gunny sack stretched over the head of the barrel for a strainer. Finally fill the barrel with water, stir thoroughly, and the mixture is ready for use. Prepared in this way the cost of 1 gallon of the mixture will not exceed 1 cent, the price of copper sulphate being 7 cents per pound and lime 30 cents per bushel. In all cases it is desirable to use powdered copper sulphate, as it costs but little more and dissolves much more readily. It is highly important also that fresh lime be used.

It will be seen by those familiar with former suggestions made by the Department that the strength of this mixture has been diminished one-half. It was found as the result of experiments made in 1891 that a mixture of this strength, and even much weaker, gave practically as good results as the old formula, which required 6 pounds of copper sulphate and 4 pounds of lime to 22 gallons of water.

2.—AMMONIACAL SOLUTION OF COPPER CARBONATE.

In an ordinary water pail mix 5 ounces of copper carbonate with enough water to make a thick paste. Dissolve this paste in 3 pints of strong aqua ammonia; then dilute to 45 gallons. If three pints of ammonia are not sufficient to dissolve all the paste add enough to bring about this result. Copper carbonate occurs in the market in the form of a fine greenish powder. The retail price is usually 60 cents per pound. Aqua ammonia having a strength of 26° retails at 8 cents per pound. Upon this basis 1 gallon of the ammoniacal solution of copper carbonate will cost 1 cent.

In view of the fact that copper carbonate is sometimes difficult to obtain the following directions for manufacturing it are given:

In a half barrel, or some similar vessel, dissolve 3 pounds of copper sulphate in 2 gallons of hot water. In another vessel dissolve 3½ pounds of common washing soda or sal soda in 1 gallon of hot water. When cool pour the second solution slowly into the first; then as soon as all action has ceased add enough water to bring the whole up to 8 or 10 gallons and stir thoroughly. In twenty-four hours pour off the clear liquid, taking care not to disturb the sediment. Add fresh water and stir again. Again allow the solution to stand twenty-four hours, pour off the clear liquid as before; then remove the sediment, which is copper carbonate. Prepared in this way there is formed 1½ pounds of

copper carbonate at an expense for materials of approximately 18 cents per pound. The copper-carbonate paste may be immediately dissolved in aqua ammonia, using 2 gallons of the latter, or as much as may be necessary for the purpose. This concentrated fluid should be kept in well corked jugs and when ready for use should be diluted at the rate of 1 pint to 12 gallons of water.

3.—EAU CÉLESTE.

Dissolve 2 pounds of copper sulphate in 8 gallons of water. When completely dissolved add 3 pints of strong ammonia and dilute to 45 gallons. Prepared in this way the solution will cost about two-thirds of a cent per gallon.

4.—MODIFIED EAU CÉLESTE.

Dissolve 4 pounds of copper sulphate in 10 or 12 gallons of water and stir in 5 pounds of washing or sal soda; then add 3 pints of strong aqua ammonia, dilute to 45 gallons. The cost will be $1\frac{1}{2}$ cents per gallon.

HOW AND WHEN TO SPRAY.

It should always be borne in mind that no hard and fast rules can be laid down for work of this kind. Frequently the fruit-grower will have to use his own judgment, especially as regards the number of sprayings and the proper time to discontinue them. If this be not done serious results may follow. In the treatment of black-rot of the grape we have known vine-growers to continue the application of Bordeaux mixture through a protracted drought up to the time of ripening of the fruit. As a result when the time arrived to send the grapes to market they were so badly spotted with the mixture that no one would buy them. Again we have found fruit-growers thoroughly imbued with the idea that the only proper way to spray was to rush through an orchard or vineyard with some new-fangled complicated machine, applying the solutions in daubs at one point and omitting whole trees or blocks of vines at another. Such work is to be regretted, as it may be the cause of much loss to those who have acted carefully and intelligently in the matter. For example, in the case of the grape scare in New York City the past summer grape-growers all over the country were made to suffer, partly through the folly of a few overzealous individuals who upon their own responsibility made more applications than were necessary and partly through the action of a somewhat hasty Board of Health.

Before taking up the subject of treatments proper it may be well to emphasize the importance and necessity of using the right kind of machinery. A sprayer to be effective requires first of all a good strong force pump. Next in importance is a nozzle that will throw a mist-like spray and will not clog when thick fluids are used. There are plenty of machines on the market filling all these requirements. For conven-

ience they may be divided into three classes: (1) horse-power automatic machines, (2) machines drawn by horse power, but operated by hand, and (3) hand machines. All belonging to the first group may be dismissed with the statement that they are unnecessarily expensive and complicated, and will not, even in the most careful hands, do the work as thoroughly and effectively as the machines belonging to the second and third groups. Of the second group, in which the cheapest, most practical and efficient example is found in a strong, light, double-acting, double-discharge force pump mounted on a barrel, it may be said that while they can not do the work as rapidly as the machines of the first class they are more effective, much cheaper, and far less wasteful of the liquid used. To the third class belong the knapsack sprayers, which are the only ones necessary to notice in this connection. There is no question that for all moderately low-growing crops the knapsack sprayer fills every requirement. In no other machine is the work so absolutely at all times under control, it being possible to place nearly every drop of liquid exactly where it is wanted. Knapsack pumps are now used in many moderate-sized vineyards; also in places where the horse-power apparatus, owing to the nature of the land or the manner of cultivation, can not be utilized.

Many firms throughout the country, as will be seen by reference to the columns of any good agricultural paper, are engaged in the manufacture and sale of the various machines mentioned.

Taking up the question of spraying more specifically we would call attention first to apple diseases and their treatment.

TREATMENT OF APPLE SCAB.

For this disease either modified eau céleste or ammoniacal solution of copper carbonate, preferably the former, may be used. At least four sprayings should be made, the first just as the flowers are opening, the second twelve or fourteen days later, and the third and fourth at similar intervals. In case the season is wet one or two additional treatments will undoubtedly pay. For trees 15 to 18 feet high the cost of four sprayings with either of the fungicides mentioned need not exceed 20 cents per tree. When the work is done on a large scale 16 to 18 cents per tree will cover the cost of four treatments. Two additional treatments will add to the cost from 6 to 8 cents per tree.

APPLE POWDERY MILDEW.

It is only in nurseries that this disease is destructive. Seedlings are especially subject to the mildew, the leaves being attacked as soon as they appear. As a result the trees make very little growth, are bark bound, and consequently unfit for budding. The ammonical solution has proved the cheapest and most effective remedy for this disease, and five sprayings seem to be required. The first application should

be made just as the leaves start in spring. At least three other sprayings should be made at equal intervals between the time of the first treatment and the time for budding. Ten or twelve days after budding the last spraying should be made, making five in all. For blocks of 50,000 to 100,000 seedlings the total cost of the treatment, as indicated, need not exceed 8 cents per thousand. In smaller blocks the average cost per thousand trees will be somewhat greater, as it requires practically as much time to prepare to spray 25,000 trees as it does 50,000. The knapsack pump is well adapted to this work and is extensively used by nurserymen. Larger machines designed to be drawn by a horse have been described by us in Circular No. 10 of the Division of Vegetable Pathology.

TREATMENT OF PEAR SCAB, CRACKING, AND LEAF-BLIGHT.

These diseases, caused by two different species of fungi, are now successfully combated by one line of treatment. In most sections all three diseases are found associated. Bordeaux mixture has given the best results in this work, although ammoniacal solution has proved almost as effective. The only objection to the latter is that it sometimes gives the fruit a rusty appearance, which is not at all desirable. The first spraying for these diseases should be made when the trees are in flower. In ten or twelve days a second treatment should be made, followed by a third and fourth at the expiration of two and four weeks respectively. In the nursery, pear leaf-blight is often exceedingly troublesome. It may be almost entirely prevented by spraying five or six times with the Bordeaux mixture, making the first application when the leaves are about one-third grown and the others at intervals of ten or twelve days throughout the season.

The cost of treating full-grown standard trees with the Bordeaux mixture as indicated will average from 12 to 14 cents per tree. For dwarf trees the cost will range from 8 to 12 cents each. The cost of treating with the ammoniacal solution will be considerably less, probably not exceeding 10 cents for standard and 8 cents for dwarf trees. In the nursery pear seedlings can be treated six times with the Bordeaux mixture for 50 cents per thousand.

TREATMENT OF LEAF-BLIGHT OF THE CHERRY, PLUM, AND QUINCE.

This disease, which seriously damages the trees both in the nursery and orchard, may be readily held in check by the proper use of either Bordeaux mixture or the ammoniacal solution. In the orchard and nursery the directions laid down for the treatment of pear scab, cracking, and leaf-blight are applicable here.

TREATMENT OF BLACK-ROT OF THE GRAPE.

Method A.—After pruning the vineyard and putting the ground in thorough order spray the vines first, as the buds begin to swell, with Bordeaux mixture. When the leaves are one-third grown make a sec

ond application of the same fungicide, following with a third when the vines are in full bloom. After this, applications should be continued at intervals of ten or twelve days until the first signs of ripening are noticed. This will usually be three weeks or a month before the grapes are ready to pick. In no case should the treatments be continued up to the time of harvest, as this is entirely unnecessary; moreover, it is sure to render the fruit unsightly. It is important to bear in mind that in case of dry weather the sprayings should cease.

Method B.—Following the direction laid down under method *A*, with the exception that the ammoniacal solution be used instead of Bordeaux mixture.

Method C.—For the first three sprayings use the Bordeaux mixture, then substitute the ammoniacal solution for the rest of the season.

The cost of the treatment as laid down in method *A* need not exceed 2½ cents per vine. Method *B* will cost 2 cents and method *C* the same.

So far as efficacy is concerned there is little choice. All things considered, however, method *A* will doubtless prove the most satisfactory.

DOWNY MILDEW OF THE GRAPE.

When this disease occurs alone ammoniacal solution or modified eau céleste may be used. The first spraying should be made when the fruit is well formed, the others at intervals of ten or twelve days as recommended for black-rot. What is known as brown-rot is caused by the fungus of downy mildew. It is seldom that brown-rot occurs in the berries without the leaves being also affected. In regions where this happens the treatment recommended for black-rot should be followed.

In some sections eau céleste has been more effective against these diseases than any of the other fungicides. This is notably the case in northern Ohio and western New York. Eau céleste, however, sometimes injures the foliage, and we do not advise its extended use.

ANTHRACNOSE OF THE GRAPE.

Use Bordeaux mixture the same as recommended for black-rot under method *A*.

USE OF COPPER COMPOUNDS FROM A HYGIENIC STANDPOINT.

Ever since the copper compounds came into general use as fungicides the question as to their effects, hygienically considered, has received more or less attention. With the exception of the New York City Board of Health no positive stand on this question has been taken so far as we are aware. Many vague and misleading statements, however, have from time to time appeared in the horticultural and agricultural papers. Every one familiar with the situation understands why these rumors, for such they can only be considered, are sent out. They are not aimed

particularly at the practice of spraying, but are simply efforts on the part of selfish competitors to cripple the legitimate trade of more energetic and wide-awake rivals.

We take the ground that fruit sprayed with the copper compounds in accordance with the directions of the Department is harmless. No better proof of this is to be found than that shown by the experience of this country. For five years the copper compounds have been used by hundreds and thousands of fruit-growers in every part of the United States, yet in all that time not a single authenticated case of poisoning, so far as we are aware, has been brought to light. It is true a few individuals have claimed that they were made sick by eating sprayed fruit, but in all such cases careful investigations have revealed that claims of this kind were absolutely without foundation. However, we do not consider these general statements sufficient to warrant us in taking the stand as regards the harmlessness of the copper compounds when properly used. More direct testimony is readily obtained and some of this we now propose to consider. The question may properly be discussed under two heads, namely:

- (1) The present condition of our knowledge as regards the toxicology of copper; and
- (2) Are the salts found in sufficient quantity upon the fruit at the time of harvest to prove injurious to health?

No doubt the majority of people, including physicians, would answer the first statement at once by saying that copper is a poison. When we come to look carefully into the matter, however, it is found that the very best authorities differ on the subject. For more than a hundred years the question as to the poisonous nature of copper has been discussed, and yet, after reading all the testimony, it is exceedingly difficult from the evidence adduced to form a definite opinion.

In 1885 the question was discussed before the Belgium Royal Academy of Medicine for seven months, the object being to obtain some authoritative data as to the effect of copper contained in French canned vegetables on the public health. While it was finally decided that the copper compounds in foods were harmful, no direct stand as to the poisonous nature of the substances was taken. Those who antagonized the view that copper was an actual poison cited many eminent authorities to bear out their assertions. In the whole discussion, however, it was remarkable that not a single case of injury to health resulting from the daily absorption of small quantities of copper was given. Many instances were cited, however, where foods containing copper in considerable amounts were daily consumed without any ill effects whatever. It is interesting to note in this connection that notwithstanding the discussion before the Belgium Academy the law of July, 1882, prohibiting the use of copper in the re-greening of fruits was repealed by the French authorities in the Department of the Seine. It appears, therefore, from all the evidence on the subject that the question under consideration is

not settled by any means. For this reason alleged cases of poisoning with copper should receive the most careful investigation.

We presume no one will deny that copper in large or even moderate doses is unwholesome. Looking at the question from this standpoint let us consider the second part of our subject, *i. e.*, Are the salts found in sufficient quantity in connection with properly sprayed fruit at the time of harvest to cause injury to health? At this point it may be well to add that all our remarks apply to the Bordeaux mixture, which contains about twenty times as much copper as the ammoniacal solution, the only additional fungicide worthy of consideration on account of its extended use.

According to Gauthier, professor of chemistry of the faculty of medicine, Paris, an adult can absorb daily for a period of several weeks without ill effects from 0.2 to 0.5 * gram of copper sulphate, or blue vitriol. Five-tenths of a gram is usually considered the maximum amount that may be absorbed for any length of time without injury to health, although cases are on record where as high as 2, 3, and even 4 grams have been absorbed for a number of days in succession without any ill effects whatever. Some recent French investigations have shown that a dog can absorb from 15 to 25 grams of copper sulphate without injury. Sheep have been fed 43 grams per day for several days in succession without any noticeable derangement of the system.

At this point we are confronted with a somewhat complex chemical question which makes it difficult to obtain results strictly comparable. The Bordeaux mixture, as elsewhere shown, is made by the addition of lime to a solution of copper sulphate. According to recent investigations, the reaction is an exceedingly complicated one, the details of which are unnecessary here. It has generally been accepted that the mixture as sprayed upon the vines consists for the most part of copper hydrate, which upon drying becomes an insoluble compound. We have, therefore, first of all the question to consider whether the hydrate is as likely to prove injurious to health as the sulphate in solution. No direct investigations upon this point have, so far as we know, been made. It has been shown, however, that doses of copper four to five times greater can be administered in an insoluble than in a soluble state. The question now briefly stated resolves itself into this: May we, without assuming too much, use the facts bearing on the harmfulness or harmlessness of copper sulphate when considering copper hydrate and copper oxide? We believe that this assumption is not only admissible but is erring upon the safe side; in other words, that if an adult can safely absorb 0.5 gram of copper sulphate a day without injury, he may with much less fear of ill effects absorb the same quantity of copper hydrate and copper oxide. In fact, as regards the ill effects of the latter, hygienically considered, there is a great deal of evidence which will be considered later.

*1 gram equals 15.438 grains.

Accepting, then, 0.5 gram as the maximum amount of copper in any of the forms discussed that may with safety be daily absorbed, let us see how these figures compare with the quantity of this metal found in connection with properly sprayed fruits as well as some other foods and drinks. Analyses to determine the amount of copper on sprayed grapes have been made in Germany, France, America, and other countries. The result of all these show that grapes sprayed intelligently rarely contain more than 5 milligrams (0.005 gram) of copper per kilogram, the average being from $2\frac{1}{2}$ to 3 milligrams per kilogram. In other words, 1,000,000 pounds of grapes sprayed in the usual way with the Bordeaux mixture would contain from $2\frac{1}{2}$ to 5 pounds of copper. To reduce the figures still further, each 1,000 pounds of fruit would contain 17.5 to 35.0 grains of copper. On this basis an adult may eat from 300 to 500 pounds of sprayed grapes per day without fear of ill effects from the copper. This shows how ridiculously absurd are the statements that fruits properly sprayed with the Bordeaux mixture or any other copper compound are poisonous.

Turning our attention to another phase of the subject, let us consider some other articles of food and drink in no way connected with spraying. In the first place, it has recently been shown that grapes which have never been treated with any fungicide may contain as much as 2 milligrams of copper per kilogram—two parts in a million, or practically the same as the average amount found in connection with sprayed fruit. Finding copper, therefore, in connection with fruit is no indication that such fruit has been sprayed with the copper compounds. Perhaps if this fact is remembered in the future it may prevent hasty conclusions and consequent annoyance.

According to numerous analyses wheat may contain from 4 to 10 milligrams of copper per kilogram, the average being 7.2 milligrams per kilogram. The United States exported to Europe and other foreign countries in 1890, 54,387,767 bushels of wheat, weighing approximately 3,263,266,020 pounds or 1,480,217,466 kilograms. If each kilogram of wheat contained 7.2 milligrams of copper, then there were 10,657 kilograms or 23,495 pounds of this metal sent out of the country in wheat alone. In the face of these figures we do not see how any foreign country can logically object to American fruits on the ground that they contain copper without also objecting to wheat.

Wheat, however, does not contain anything like as much copper as some other foods and drinks. Beef and sheep liver, according to reliable and repeated analyses, contain respectively from 56 to 58 and 35 to 41 milligrams of metallic copper per kilogram of fresh substance, while in chocolate the enormous amount of 125 milligrams to the kilogram has been found. In conclusion, it is only necessary to call attention to one other matter to show how unjust and discriminating it would be to condemn American fruits on the ground that they contain copper in unwholesome quantities. Brief reference has already been made to the re-greening of vegetables, as practiced by the French. Peas, beans,

cucumbers, and similar products are plunged for eight or ten minutes in a solution of copper sulphate in order to fix the natural green coloring matter. After removing the vegetables from the copper sulphate solution they are washed in pure water, placed in jars containing a solution of common salt, sealed and sterilized by heat.

The analyses of such vegetables show that they contain copper in considerable quantity, as will be seen by consulting the table below:

Table showing copper in 1 kilogram of re-greened canned vegetables.

Vegetables.	Authority.	Amount of copper.
		<i>Milligrams.</i>
Peas.....	Galippe.....	48 to 60
Do.....	Carles.....	70 to 210
Do.....	Gautier.....	11 to 125
Beans.....		49 to 99
Cucumbers.....	Magnier.....	2
Tomatoes.....	Sestini.....	50 to 354

It appears from the foregoing that vegetables re-greened by the copper process may contain from two to sixty times as much of the metal as sprayed grapes. In other words, if 1,000,000 pounds of sprayed grapes contain 5 pounds of copper, 1,000,000 pounds of re-greened vegetables would contain from 38 to 150 pounds of the metal. Great Britain imported over 14,000,000 pounds of canned vegetables from France in 1890, and it is safe to say that these vegetables contained more than twenty times as much copper as all the sprayed fruit in the United States combined.

Common Mealybugs and Aphids
DIV. INSECTS.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 19.

IMPORTANT INSECTICIDES:

DIRECTIONS FOR THEIR PREPARATION AND USE.

BY

C. L. MARLATT,
FIRST ASSISTANT ENTOMOLOGIST.

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Farmers' Bulletin No. 1. The What and Why of Agricultural Experiment Stations. Pp. 16. Issued June, 1889.

Farmers' Bulletin No. 2. The Work of the Agricultural Experiment Stations. Pp. 16. Issued June, 1889.

Farmers' Bulletin No. 3. The Culture of the Sugar Beet. Pp. 24. Issued March, 1891.

Farmers' Bulletin No. 4. Fungous Diseases of the Grape and their Treatment. Pp. 12. Issued March, 1891.

Farmers' Bulletin No. 5. Treatment of Smuts of Oats and Wheat. Pp. 8. Issued February, 1892.

Farmers' Bulletin No. 6. Tobacco: Instructions for its Cultivation and Curing. Pp. 8. Issued February, 1892.

Farmers' Bulletin No. 7. Spraying Fruits for Insect Pests and Fungous Diseases, with a Special Consideration of the Subject in its Relation to the Public Health, Pp. 20. Issued April, 1892.

Farmers' Bulletin No. 8. Results of Experiments with Inoculation for the Prevention of Hog Cholera. Pp. 40. Issued May, 1892.

Farmers' Bulletin No. 9. Milk Fermentations and their Relations to Dairying. Pp. 24. Issued July, 1892.

Farmers' Bulletin No. 10. The Russian Thistle and other Troublesome Weeds in the Wheat Region of Minnesota and North and South Dakota. Pp. 16. Issued April, 1893.

Farmers' Bulletin No. 11. The Rape Plant: Its History, Culture, and Uses. Pp. 20. Issued June, 1893.

Farmers' Bulletin No. 12. Nostrums for Increasing the Yield of Butter. Pp. 16. Issued June, 1893.

Farmers' Bulletin No. 13. Cranberry Culture. Pp. 16. Issued January 30, 1894.

Farmers' Bulletin No. 14. Fertilizers for Cotton. Pp. 32. Issued March, 1894.

Farmers' Bulletin No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. Pp. 8. Issued April, 1894.

Farmers' Bulletin No. 16. Leguminous Plants for Green Manuring and for Feeding. Pp. 23. Issued April, 1894.

Farmers' Bulletin No. 17. Peach Yellows and Peach Rosette. Pp. 20. Issued June, 1894.

Farmers' Bulletin No. 18. Forage Plants for the South. Pp. 27. Issued July, 1894.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., June 20, 1894.

SIR: I have the honor to transmit herewith, for publication as a Farmers' Bulletin, a condensed account of the more important insecticides for farm and garden use, prepared under my direction by Mr. C. L. Marlatt, first assistant entomologist. Circular No. 1, new series, of this division, and Farmers' Bulletin No. 7 contained information of this character, but these documents are out of print and since they were published some advance has been made in the matter of insecticides which necessitates the publication of some additional matter and some change in the methods of preparation of old and standard mixtures. The constant call for information of this character will warrant the publication of this bulletin in large edition.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

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IMPORTANT INSECTICIDES: DIRECTIONS FOR THEIR PREPARATION AND USE.

Without going minutely into the field of remedies and preventives for insect depredators, it is proposed to give in this bulletin brief directions concerning a few of the insecticide agents having the widest range and attended with the greatest usefulness, economy, and ease of application. These are not covered by patent, and in general it is true that the patented articles are inferior, and many of the better of them are in fact merely more or less close imitations of the standard substances and compounds hereinafter described. Only such brief references to food and other habits of the insects covered will be included as are necessary to illustrate the principles underlying the use of the several insecticide agents recommended.

RELATION OF FOOD HABITS TO REMEDIES.

For the intelligent and practical employment of insecticides it is necessary to comprehend the nature and method of injury commonly due to insects. Throwing aside, for the present purpose, the innumerable special cases of injury which necessitate peculiar methods of treatment, the great mass of the harm to growing plants from the attacks of insects falls under two principal heads based on distinct principles of food economy of insects, viz. whether they are biting (mandibulate) or sucking (haustellate), each group involving a special system of treatment.

BITING INSECTS.

Under this head comes the injury resulting from the actual consumption by the mastication and swallowing of the solid substance of some portion of the plant, as the wood, bark, leaves, flowers, or fruit. This is done by the biting or gnawing insects, such as various larvae and certain beetles and locusts, causing an injury at once apparent and readily observed and understood.

For all these insects poisons such as the arsenicals, which may be safely applied to the leaves or other parts of the plant attacked and which will be swallowed by the insect with its food, furnish the surest and simplest remedy. A direct poison should, therefore, be employed for all biting insects which feed externally, except where the parts attacked are themselves to be shortly used for the food of other animals or of man.

SUCKING INSECTS.

Under the second head is grouped the injury due to the gradual extraction or absorption of the juices of the plant, either from the bark, leaves, or fruit by such sucking insects as plant-bugs, plant-lice, scale-insects, Thrips, and also plant feeding mites, as the red spider. These insects possess, instead of biting jaws, sucking beaks or bristles, which are thrust down through the outer layers of the bark or leaves into the soft, succulent tissues beneath and used to extract the plant juices, with a resulting injury not so noticeable as in the first group, but not less serious.

It is evident that for this class of injury the application of external poisons, which penetrate little, if at all, into the plant cells, will be of trifling value, and, in fact, for all these insects it is necessary to use substances which will act externally on the bodies of the insects, either as a caustic or to smother or stifle them by closing their breathing pores or to fill the air about them with poisonous fumes. Of value also are deterrent or obnoxious substances which repel the insects. In the cases also, referred to above, where it is not desirable to use poisons for the biting insects, the use of caustic or smothering washes is always advisable.

GROUPS SUBJECT TO SPECIAL TREATMENT.

The general grouping outlined above relates to the species which live and feed upon the exterior of plants for some portions or all of their lives, and includes the great majority of the injurious species. Certain insects, however, owing to peculiarities of habit, inaccessibility, or other causes, require special methods of treatment. Of these two groups properly come within the scope of this bulletin: (1) Those working beneath the soil, or subterranean insects, such as the white grubs, root-maggots, root lice, etc., and (2) insects affecting stored products, as various grain and flour pests.

Three other groups, which include species requiring very diverse methods of treatment, and therefore not coming within the limits of this bulletin, are (1) the internal feeders, such as wood, bark, and stem-borers, leaf-miners, gall insects, and species living within fruits: (2) household pests, and (3) animal parasites.

In brief, the classification of insects outlined above, based on mode of nourishment and indicating groups amenable to similar remedial treatment, simply stated, is as follows:

- I. External feeders:
 - (a) Biting insects.
 - (b) Sucking insects.
- II. Internal feeders.
- III. Subterranean insects.
- IV. Insects affecting stored products.
- V. Household pests.
- VI. Animal parasites.

INSECTICIDES FOR EXTERNAL BITING INSECTS (FOOD POISONS).

The arsenical compounds have supplanted all other substances for the insects falling under this heading. Two compounds are in common use, viz, Paris green and London purple.* The use of powdered white arsenic is not recommended, on account of its great liability to scald foliage and on account of its color to be mistaken for harmless substances. Of the two first mentioned Paris green is the stronger insecticide, acting quickly, and is less liable to burn foliage. London purple has the advantage of cheapness, and, being more finely powdered, is kept more easily suspended in water. The former can be had in 14-pound or larger cans at 20 cents per pound, and the latter at 10 cents per pound by the barrel.

HOW TO APPLY ARSENICALS.

For all ordinary cases, the use of these poisons in water in the form of a spray is advisable. In the cotton fields of the South, where prompt and economical action against the cotton worm is essential, the dry application of these poisons is more popular. The latter form of treatment is feasible also for low-growing crops, such as the potato, but can not be employed in the case of orchard and shade trees, and is less satisfactory than the use in a spray, in being wasteful, in lacking uniformity, and in being more apt to injure foliage. The cheapness and rapidity of the dry method gives it a value, however, against the cotton worm, and the usual mode of application is as follows:

The dry method.—A pole 5 to 8 feet long, and about 2 inches in diameter with a three-fourths inch hole bored through it within 6 inches of either end is used. To each end is securely tacked a bag of "8-oz. osnaburg cloth," 1 foot wide and 18 inches to 2 feet long, so that

* A third arsenical which promises well, arsenate of lead, has lately been experimented with by the Gypsy Moth Commission. While not urging that this insecticide has advantages over Paris green, it is held that it has the merit of showing on the leaves, indicating at once which have been sprayed, remains much more easily suspended in water, and may be used in large proportions without danger to foliage. It has recently been extensively tested at the Department, and a strength as great as 1 pound to 2 gallons of water has been used on tender foliage of the peach and Osage orange without injury. Good results have attended its use also against the imported elm leaf-beetle. The insecticide results were not better, however, than with Paris green; but for such sensitive foliage as that of the peach, or where no risk of scalding may be taken, I am inclined to believe that it will prove useful.

This insecticide is prepared by combining, approximately, 3 parts of arsenate of soda with 7 parts of acetate of lead. These substances unite chemically and form a fine, white powder which remains easily in suspension. As now used by the commission, 10 pounds of the arsenate of lead are used with 150 gallons of water, 2 quarts of glucose being added to cause the insecticide to adhere longer to the leaves. Prof. Fernald's experience and our own would indicate that from one-fourth to one-half this strength will answer for most larvæ—the larvæ of the gypsy moth proving to be unusually resistant to the action of poisons. The arsenate of lead costs the commission 7 cents a pound wholesale, and glucose \$16 a barrel.

the powdered poison can be introduced into the bag with a funnel through the holes at the ends of the pole. The bags are filled with undiluted Paris green, which is generally preferred to London purple on account of its quicker action, and the apparatus is carried, on horse or mule back, through the cotton fields, dusting 2 or 4 rows at once. The shaking induced by the motions of the animal going at a brisk walk or at a trot is sufficient to dust the plants thoroughly, or the pole may be jarred by hand. The application is preferably made in the early morning or late evening when the dew is on, to cause the poison to adhere better to the foliage.

From 1 to 2 pounds are required to the acre, and from 10 to 20 acres are covered in a day. The occurrence of heavy rains will necessitate a second application, but frequently one will suffice. This simple apparatus, on account of its effectiveness and cheapness, is employed throughout the cotton belt to the general exclusion of more complicated and expensive machinery.

With the larger machines for the dry distribution of poisons, arsenicals are diluted with 10 parts of flour, lime, or ground gypsum, and from 60 to 75 acres can be covered in a day by using relays of men and teams. Greater uniformity is secured with these machines in distribution of the poisons, but their cost (from \$30 to \$60) prevents their general use.

The planter should have a good supply of poison on hand and apparatus for its application prepared in advance, since when the worm puts in an appearance its progress is very rapid, and a delay of a single day may result in material damage to the crop.

If small garden patches are dusted with poison by this, or similar means from bags, it is advisable always to dilute the poison with 10 parts of flour, or preferably lime; and for application to vegetables which may soon be used for food, as the cabbage, 1 ounce of the poison should be mixed with 6 pounds of flour or lime, and dusted merely enough to show evenly over the surface.

The wet methods.—Either Paris green or London purple may be used at the rate of 1 pound to 100 to 250 gallons of water, or 1 ounce to 6 to 15 gallons. The greater dilutions are for the tender foliage of the peach, and an average of 1 pound to 150 gallons of water is a good strength for general purposes. The poison should be first made into a thin paste in a small quantity of water, and a more than equal weight of powdered lime added to take up the free arsenic and remove or lessen the danger of scalding. An excess of lime will do no injury. The poisons thus mixed should be strained into the spray tank or reservoir, care being taken that all the poison is pulverized and washed through the meshes of the strainer. The use of the lime is especially desirable in the case of the peach and plum, the foliage of which, particularly the former, is very tender and easily scalded. To the stronger foliage of the apple and most shade trees, Paris green may be applied

at the strength of 1 pound to 150 gallons of water without danger; with London purple it is always better to use the lime.

If it is desirable to apply a fungicide at the same time, as on the apple for the codling moth and the apple scab fungus, the Bordeaux mixture* may be used instead of water, adding the arsenical to it at the same rate per gallon as when water is used. The lime in this fungicide neutralizes any excess of free arsenic, and makes it an excellent medium for the arsenical.

TIME TO SPRAY.

For the codling moth, the apple and pear should receive the first application as soon as the blossoms fall, which is also the time for the treatment of the scab fungus; the second spraying should be given one or two weeks later, just before the fruit turns down on the stem or when it is from one-fourth to one-half inch in diameter. The first spraying reaches the eggs laid by the moth in the flower end of the fruit about the time of the falling of the blossoms, and the second the later egg-laying by the more belated moths, and when the first coating of poison will probably have been washed off by rains. The young larva, eating its way from without into the fruit gets enough of the poison to destroy it. This treatment reaches, at the same time, a large number of leaf-feeding enemies of these fruit trees.

For the Curculio of the stone fruits—plum, cherry, peach, etc.—two or three applications should be made: the first before the trees bloom or as soon as the foliage is well started; the second at the time of the exposure of the young fruit by the falling of the blossoms, and perhaps a third a week later, particularly if rains have intervened after the last treatment. The poison here acts to destroy the parent Curculio instead of the young larvae which, hatching from eggs placed beneath the skin of the fruit are not affected by the poison on the outside. The adult Curculio, however, as soon as it comes from its winter hibernation feeds on the foliage before the trees bloom, and later on the young fruit also and is destroyed by the arsenical before its eggs are deposited.

For leaf-feeding insects in general such as the potato-beetles and larvae, blister-beetles, elm leaf-beetle, maple worm, etc., the application should be made at the earliest indication of injury. Fruit trees should never be sprayed when in bloom on account of the liability of poisoning honey bees or other insects useful as cross-fertilizers.

The Bordeaux mixture is made by combining 6 pounds of copper sulphate and 4 pounds of quick lime with water to make 50 gallons. The copper sulphate is dissolved in water (hot, if prompt action is desired) and diluted to about 25 gallons. The fresh lime is slaked in water, diluted to 25 gallons, and strained into the copper solution, after which the whole is thoroughly stirred with a paddle. Both the copper and the lime mixtures may be kept in strong solution as stock mixtures, but when combined should be promptly used, as the Bordeaux mixture deteriorates on standing.

It must be remembered that these arsenicals are very poisonous, and should be so labeled. If ordinary precautions are taken there is no danger to man or team attending their application, and the wetting of either, which cannot always be avoided, is not at all dangerous on account of the great dilution of the mixture, and no ill results whatever have resulted from this source.

The poison disappears from the plants almost completely within 20 to 25 days, and even if the plants were consumed shortly after the application, an impossible quantity would have to be eaten to get a poisonous dose. To illustrate, in the case of the apple, if the entire fruit were eaten, core and all, it would take several barrels at a single sitting to make a poisonous dose (Riley), and with the cabbage dusted as recommended above, 28 heads would have to be eaten at one meal to reach this result (Gillette). It is preferable, however, to use other insecticides in the case of vegetables soon to be eaten, and thus avoid all appearance of danger.

INSECTICIDES FOR EXTERNAL SUCKING INSECTS (CONTACT POISONS).

Two classes of insecticides have proven themselves far superior to all others for this group of insects, viz, (1) the kerosene emulsions and resin washes, and (2) the gas treatment. The simpler remedies, such as soap and lye washes, tobacco decoction, etc., need no special explanation. The Pyrethrum powders, Persian insect powder, and Buhach are effective, but too expensive for any but limited applications or indoor use.

THE KEROSENE WASHES.

Pure kerosene is very destructive to plant life, but diluted it may be safely applied, and the emulsions made by combining it with either soap or milk are so far the most satisfactory means of diluting it discovered.

The kerosene and soap emulsion.—This is made after the following formula:

Kerosene	gallons..	2
Soap	pound..	$\frac{1}{2}$
Water	gallon..	1

The soap, first finely divided, is dissolved in the water by boiling, and then added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently by being pumped back upon itself with a force pump and direct-discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After about five minutes' pumping, the emulsion should be perfect, and the mixture will have increased from one third to one-half in bulk, and assumed the consistency of cream. It should adhere to glass without oiliness. Well made, the emulsion will keep indefinitely, or may be diluted for immediate application.

The use of whale-oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, and does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft soap answers very well, and 1 quart of it may be taken in lieu of the hard soaps.

In limestone regions or where the water is very hard some of the soap will combine with the lime or magnesia in the water and more or less of the oil will be freed, especially when the emulsion is diluted. Before using, such water should be broken with lye, or rain water used, but better than either, use the milk emulsion, with which the character of the water whether hard or soft does not affect the result.

The kerosene and milk emulsion.—The formula is as follows:

Kerosene	gallons..	2
Milk (sour)	gallon..	1

Heating is unnecessary in making the milk emulsion, which otherwise is churned as in the former case. The change from a watery liquid to a thick buttery consistency, much thicker than with the soap, takes place very suddenly after three to five minutes' agitation. With sweet milk difficulty will frequently be experienced, and if the emulsion does not result in five minutes, the addition of a little vinegar will induce prompt action. It is better to prepare the milk emulsion from time to time for immediate use unless it can be stored in quantity in air-tight jars, otherwise it will ferment and spoil after a week or two.

How to use the emulsion.—During the growing period of summer, for most plant-lice and other soft-bodied insects, dilute the emulsion with from 15 to 20 parts of water; for the red spider and other plant mites the same with the addition of 1 ounce of powdered sulphur to the gallon; for scale insects, the larger plant-bugs, larvæ, and beetles, dilute with from 7 to 9 parts water; apply with spray pump.

For winter applications to the trunks and larger limbs of trees, in the dormant and leafless condition, to destroy scale-insects, stronger mixtures may be used even to the pure emulsion, which may be applied with brush or sponge. This latter is heroic treatment and only advisable in cases of excessive infestation, and in general it is much better and safer to defer the treatment until the young scales hatch in the spring, when the 9-times diluted wash may be used with more certain results and without danger to plants. The winter treatment should usually be followed by a use of the spring wash to destroy any young which may come from female scales escaping the stronger wash.

Pure kerosene.—The pure oil may be applied as a winter wash to the older parts of plants either in a spray or with a sponge, using the least possible quantity. Its use is not advised except in exceptionally bad

cases of infestation and during the dormant period, and should never be attempted after the first sign of spring growth appears.

In many cases plant bugs and beetles may be jarred into cloths saturated with kerosene or into pans with water and oil and destroyed, where it would be unsafe or inadvisable to spray the plants themselves.

As a remedy against the mosquito, kerosene has proven very effective (Howard). It is employed to destroy the larvæ of the mosquitoes in their favorite breeding places in small pools, still ponds, or stagnant water, and where such bodies of water are not sources of drinking supply or of value for their fish, especially in the case of temporary pools from rains, which frequently breed very disagreeable local swarms, the use of oil is strongly recommended. The kerosene is applied at the rate of one ounce to 15 square feet of water surface, and forms a uniform film over the surface and destroys all forms of aquatic insect life, including the larvæ of the mosquito and also the adult females coming to the water to deposit their eggs. The application retains its efficiency for several weeks, even with the occurrence of heavy rains.

THE RESIN WASHES.

These washes have proved of greatest value, particularly against red scale (*Aspidiotus aurantii*) in California, and will be of use in all similar climates where the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and where, owing to the warmth, the multiplication of the scale-insects continues almost without interruption throughout the year. Where rains are liable to occur at short intervals, and in the northern States, the quicker-acting and stronger kerosene washes are preferable. The resin washes act by contact, having a certain caustic effect, but principally by forming an impervious coating over the scale-insects, thereby smothering them. The application may be more liberal than with the kerosene washes, the object being to thoroughly wet the bark.

The wash is made as follows:

Resin.....	pounds..	20
Caustic soda.....	do.....	5
Fish oil.....	pints..	2½
Water to make.....	gallons..	100

The ordinary commercial resin is used and the caustic soda is that put up for soap establishments in large 200-pound drums. Smaller quantities may be obtained at soap factories. These substances should be finely broken up to hasten action and placed, with the oil in a large kettle with sufficient water to cover them. Boiling should be continued for one or two hours with occasional additions of cold water, or until the compound will mix perfectly in water instead of breaking up into yellowish flakes. The undiluted wash is pale yellow; intermixed with water it becomes dark reddish-brown. It may be kept in concentrated form and diluted as required.

A stronger wash is necessary for the more resistant San José scale (*Aspidiotus perniciosus*), and for this the dilution should be one third less or to 66 $\frac{2}{3}$ gallons instead of 100. This stronger mixture is a winter wash, and is only to be applied during the dormant period; in the growing season it will cause the loss of foliage and fruit.

MEANS OF APPLYING THE FOREGOING INSECTICIDES.

For the dry use of powders the dusting bags already described are very satisfactory, or for garden work some of the small powder bellows and blowers are excellent. The best of these cost about \$2 each and are on the market in many styles.

Better apparatus is required for the wet applications where successful results require the breaking up of the liquid into a fine mist-like spray. The essential features of such an apparatus are a strong force pump, one-half inch cloth-reinforced hose, and a suitable spray tip. The size of the apparatus will depend on the amount of vegetation to be treated. For limited garden work and for the treatment of small plants the knapsack pumps or the small bucket force pumps are suitable, the former costing about \$14 and the latter from \$6 to \$9.

Ready fitted pumps, knapsack and others, for the application of insecticides are now made by all the leading pump manufacturers of this country and also large reservoirs with pump attached for extended orchard operations, the cost of these latter ranging from \$25 to \$75. This outlay may be greatly reduced by the purchase of a strong pump with nozzle and hose, all costing from \$15 to \$20, and combining it with a strong tank of 150 or more gallons' capacity, to be mounted on a wagon or cart or mounting the pump on the end of a strong barrel.

A prime essential in spraying, especially where the large reservoirs are employed, is to keep the liquid constantly agitated to prevent the settling of the poison to the bottom of the tank. This may be accomplished by constant stirring with a paddle, by shaking, but preferably by throwing a stream of the liquid back into the tank. Many of the larger pumps are now constructed with two discharge orifices with this end in view, and the use of such is recommended.

In spraying the object is to coat every leaf and part of the plant as lightly as feasible with thoroughness, and to avoid waste in doing this a mist spray is essential. The application to any part should stop when water begins to drip from the leaves. A light rain will not remove the poison, but a dashing one will probably necessitate a renewal of the application.

THE GAS TREATMENT.

The hydrocyanic acid gas treatment of scale-infested trees has hitherto been exclusively confined to California, but recently has been introduced in the East by the Department to combat the San José scale. Briefly it consists in inclosing the tree with a tent and filling the lat-

ter with the poisonous fumes generated with potassium cyanide and sulphuric acid.

The outfit.—The tents are made of blue or brown drilling or 8-ounce duck and painted, or oiled with linseed oil, to make them as near airtight as possible. They are placed over the trees by hand or with poles in case of small trees, but with trees over 10 feet high some sort of a tripod or derrick is used. The outfit for medium-sized trees—tent and derrick—will cost from \$15 to \$25. A tent for trees 26 feet tall by 60 feet in circumference costs as much as \$60.

The chemicals.—Commercial fused potassium cyanide (costing in bulk 40 cents per pound), commercial sulphuric acid (at $3\frac{1}{2}$ cents per pound), and water are used in generating the gas, the proportions being 1 ounce by weight of the cyanide, slightly more than 1 fluid ounce of the acid, and 3 fluid ounces of water to every 150 cubic feet of space inclosed.

The method.—The generator, which may be any glazed earthenware vessel of 1 or 2 gallons' capacity, is placed within the tent under the tree and the water, acid and cyanide, the latter broken up, put in in the order named, after which the operator withdraws from the tent. The tent is allowed to remain on the tree for one-half hour for large trees or fifteen minutes for small ones. The treatment is best made on cloudy days, early in the morning, late in the evening, or at night. Bright, hot sunlight is liable to cause injury to the foliage, which, however, may be largely avoided by using tents of dark material or painted black.

Three or four men can operate six tents at once, and the expense under such conditions, not counting the cost of the outfit, need not be more than 10 cents per tree.

REMEDIES FOR SUBTERRANEAN INSECTS.

Almost entire dependence is placed on the caustic washes, or those that act externally, for insects living beneath the soil on the roots of plants, including both sucking and biting insects, prominent among which are the white grubs, maggots in roots of cabbage, radishes, onions, etc., cutworms, wire-worms, apple and peach root-lice, the grape phylloxera, and many others.

The insecticide must be one that will go into solution and be carried down by water. Of this sort are the kerosene emulsions and resin wash, the former preferable, the potash fertilizers, muriate and kainit, and bisulphide of carbon. Submersion, wherever the practice of irrigation or the natural conditions make it feasible, has also proven of the greatest service against the phylloxera.

Kerosene emulsion and resin wash.—Either the kerosene and soap emulsion or the resin wash, the former diluted 15 times and the latter at the strength of the winter mixture, are used to saturate the soil

about the affected plants and either left to be carried down by the action of rains or washed down to greater depths by subsequent waterings.

For the grape phylloxera or the root-louse of the peach or apple, make excavations 2 or 3 feet in diameter and 6 inches deep about the base of the plant, and pour in 5 gallons of the wash. If not a rainy season, a few hours later wash down with 5 gallons of water and repeat with a like amount the day following. It is better, however, to make this treatment in the spring when the more frequent rains will take the place of the waterings.

For root maggots enough of the wash is put along at the base of the plant to wet the soil to a depth of 1 to 2 inches, preferably following after an hour with a like amount of water.

For white grubs in strawberry beds or in lawns the surface should be wetted with kerosene emulsion to a depth of 2 or 3 inches, following with copious waterings to be repeated for two or three days. The larvæ go to deeper and deeper levels and eventually die.

Potash fertilizers.—For white grubs, wire-worms, cutworms, corn root-worms, and like insects, on the authority of Prof. J. B. Smith, either the kainit or muriate of potash, the former better, are broadcasted in fertilizing quantities, preferable before or during a rain so that the material is dissolved and carried into the soil at once. These not only act to destroy the larvæ in the soil but are deterrents, and truck lands constantly fertilized by these substances are noticeably free from attacks of insects. This, in a measure, results from the increased vigor and stronger resistant power of the plant, which latter of itself more than compensates for the cost of the treatment. The value of these fertilizers against the wire-worms is, however, questioned by Prof. J. H. Comstock.

For the root-louse of peach and apple work the fertilizers into the general surface of the soil about the trees, or put it in a trench about the tree 2 feet distant from the trunk.

For cabbage and onion maggots apply in little trenches along the roots at the rate of 300 to 500 pounds to the acre, and cover with soil.

These fertilizers (and the nitrate of soda is nearly as good) are also destructive to the various insects which enter the soil for winter hibernation or to undergo transformation.

Bisulphide of carbon.—This is the great French remedy for the phylloxera, 150,000 acres being now subjected to treatment with it, and applies equally well to all other root-inhabiting lice. The treatment is made at any season except the period of ripening of the fruit, and consists in making holes about the vines 1 foot to 16 inches deep and pouring into each about one-half ounce of bisulphide and closing the hole with the foot. These injections are made about 1½ feet apart, and not closer to the vines than 1 foot. It is better to make a large number of small doses than a few large ones. Hand injectors

and injecting plows are employed in France to put the bisulphide into the soil about the vines, but a short stick or iron bar may be made to take the place of these injectors for limited tracts.

For root maggots a teaspoonful is poured into a hole at the base of the plant, covering as above.

For ant nests an ounce of the substance is poured into each of several holes made in the space occupied by the ants, the openings being then closed, or the action is made more rapid by covering with a wet blanket for ten minutes and then exploding the vapor at the mouth of the holes with a torch, the explosion driving the fumes more thoroughly through the soil.

Submersion.—This very successful means against the phylloxera is now practiced over some 75,000 acres of vineyards in France which were once destroyed by the grape root-louse, and the production and quality of fruit has been fully restored. In this country it will be particularly available in California and in all arid districts where irrigation is practiced, otherwise it will be too expensive to be profitable. The best results are secured in soils in which the water will penetrate rather slowly, or from 6 to 18 inches in twenty-four hours; in loose, sandy soils it is impracticable on account of the great amount of water required. Submersion consists in keeping the soil of the vineyard flooded for from eight to twenty days after the fruit has been gathered and active growth of the vine ceased, or during September or October, but while the phylloxera is still in active development. Early in September eight to ten days will suffice; in October, fifteen to twenty days, and during the winter, as was formerly practiced, forty to sixty days. Supplementing the short fall submergence a liberal July irrigation, amounting to a forty-eight-hour flooding, is customary to reach any individuals surviving the fall treatment, and which at this season are very susceptible to the action of water.

To facilitate the operation vineyards are commonly divided by embankments of earth into square or rectangular plots, the former for level and the latter for sloping ground, the walls being protected by coverings of reed grass, etc., during the first year, or until they can be seeded to some forage plant.

This treatment will reach other root-attacking insects or those hibernating beneath the soil, and, in fact, is a very ancient practice in certain oriental countries bordering the Black Sea and the Grecian Archipelago.

REMEDIES FOR INSECTS AFFECTING GRAIN AND OTHER STORED PRODUCTS.

The chief loss in this direction from insects is to grains in farmers' bins, or grain or grain products in stores, mills, and elevators. Fortunately, the several important grain insects are amenable to like treatment. Aside from various important preventive considerations, such

as the thorough cleansing of bins before refilling, constant sweeping, removal of waste harboring insects from all parts of granaries and mills, and care to prevent the introduction of "weeviled" grain, there are three valuable remedial measures, viz, agitation of the grain, heating, and dosing with bisulphide of carbon.

The value of agitation or handling grain is well known, and whenever, as in elevators, grain can be transferred or poured from one bin into another grain pests are not likely to trouble. The benefit will depend upon the thoroughness of the agitation, and in France machines for shaking the grain violently have been used with success.

Raising the temperature of the grain in closed retorts or revolving cylinders to 130° to 150° F. will kill the inclosed insects if continued for from three to five hours, but is apt to injure the germ, and is not advised in case of seed stock. The simplest, cheapest, and most effectual however, is the use of bisulphide of carbon.

BISULPHIDE OF CARBON.

This is a colorless liquid with very offensive odor which, however, passes off completely in a short time. It readily volatilizes and the vapor, which is very deadly to insect life, is heavier than air and settles and fills any compartment or bin in the top of which the liquid is placed. It may be distributed in shallow dishes or tins or in saturated waste on the top of grain in bins, and the gas will settle and permeate throughout the mass of the grain. In large bins, to hasten and equalize the operation, it is well to put a quantity of the bisulphide in the center of the grain by thrusting in balls of cotton or waste tied to a stick and saturated with the liquid, or by means of a gas pipe loosely plugged at one end, down which the liquid may be poured and the plug then loosened with a rod. In moderately tight bins no further precaution than to close them well need be taken, but in open bins it will be necessary to cover the top with a blanket to prevent the too rapid dissipation of the vapor. The bins or buildings should be kept closed from twenty-four to thirty-six hours, after which a thorough airing should be given them.

Limited quantities at a time may often be advantageously subjected to treatment in small bins before being placed for long storage in large masses, and especially whenever there is danger of introducing infested grain.

The bisulphide is applied at the rate of 1 pound to the ton of grain, or a pound to a cubic space 10 feet on a side.

In the case of mills, elevators, or larger granaries the application may be best made on Saturday night, leaving the building closed over Sunday, with a watchman without to see that no one enters and to guard against fire. The bisulphide should be first distributed in the lower story, working upwards to avoid the settling vapor, using the substance very freely, in waste or dishes, at all points of infestation and over bins throughout the building.

This insecticide may also be used in other stored products, as peas, beans, etc., and very satisfactorily where the infested material can be inclosed in a tight chest or closet for treatment.

The bisulphide costs, in 50-pound cans, 10 cents per pound, and in small quantities of druggists, 25 to 35 cents per pound.

Caution.—The bisulphide may be more freely employed with milling grain than that intended for seeding, since used excessively it is liable to injure the germ. It must always be remembered that the vapor is highly inflammable and explosive and that no fire should be in the building or lighted cigars, etc., during its use. If obtained in large quantities it should be kept in tightly closed vessels and away from fire, preferably in a small outbuilding.

CONTROL OF INSECTS BY CULTURAL METHODS.

It is much easier to ward off an attack of insects or to make conditions unfavorable to their multiplication than to destroy them after they are once in possession; and in controlling them methods and systems of farm and orchard culture have long been recognized as of the greatest value—more so even than the employment of insecticides, which, in most cases, can only stop an injury already begun. Insects thrive on neglect, multiply best in land seldom or never cultivated, and winter over in rubbish, prunings, or the undisturbed soil about their food plants, and become, under these conditions, more numerous every year. It is a fact of common observation that it is the neglected farm, vineyard, or orchard filled with weeds or wild growth which is certain to be stocked with all the principal insect enemies; and, on the other hand, thorough and constant culture, with the removal and burning of prunings, stubble, and other waste, the collection and destruction of fallen and diseased fruit, and the practice, where possible, of fall plowing to disturb the hibernating quarters of field insects, will almost certainly be accompanied by comparative immunity from insect pests.

The vigor and healthfulness of plant growth has also much to do with freedom from insect injury, such plants seeming to have a native power of resistance which renders them in a measure distasteful to most insects, or at least able to throw off or withstand their attacks. A plant already weakened, however, or of lessened vitality from any cause, seems to be especially sought after, is almost sure to be the first affected, and furnishes a starting point for general infestation. Anything, therefore, which aids good culture in keeping plants strong and vigorous, such as the judicious use of fertilizers, will materially assist in preventing injury.

To the constant cropping of large areas of land, year after year to the same staple, is largely due the excessive loss from insects in this country as compared with European countries, because this practice furnishes the best possible conditions for the multiplication of the ene-

mies of such crops. A most valuable cultural means, therefore, is a system of rotation of crops which will prevent the gradual yearly increase of the enemies of any particular staple by the substitution every year or two of other cultures not subject to the attacks of the insect enemies of the first.

With such insects as the Hessian fly, the squash borers, and many others which have regular times of appearance, much can be done, also, by the planting of early or late varieties, or by deferring seeding so as to avoid the periods of excessive danger. Wherever possible, varieties should be selected which experience has shown to be resistant to insect attack. Familiar illustrations of such resistant varieties in all classes of cultivated plants will occur to every practical man, and a better instance of the benefit to be derived from taking advantage of this knowledge can not be given than the almost universal adoption of resistant American vines as stocks for the regeneration of the vineyards of France destroyed by the phylloxera.

These general notes are by no means new, but their importance justifies their repetition, as indicating the best preventive measures in connection with the remedial ones already given.

THE PROFIT IN REMEDIAL MEASURES.

The overwhelming experience of the past dozen years makes it almost unnecessary to urge, on the ground of pecuniary returns, the adoption of the measures recommended in the foregoing pages against insects. To emphasize the value of such practice, it is only necessary to call attention to the fact that the loss to orchard, garden, and farm crops frequently amounts to from 15 to 75 per cent of the entire product, and innumerable instances could be pointed out where such loss has been sustained year after year, while now, by the adoption of remedial measures, large yields are regularly secured with an insignificant expenditure for treatment. It has been established that in the case of the apple crop, spraying will protect from 50 to 75 per cent of the fruit which would otherwise be wormy, and that in actual marketing experience the price has been enhanced from \$1 to \$2.50 per barrel, and this at a cost of only about 10 cents per tree for labor and material.

In the case of one orchard in Virginia, only one-third of which was sprayed, the result was an increase in the yield of sound fruit in the portion treated of nearly 50 per cent, and an increase of the value of this fruit over the rest of 100 per cent. The loss from not having treated the other two-thirds was estimated at \$2,500. The saving to the plum crop, and other small fruits, frequently amounts to the securing of a perfect crop where otherwise no yield whatever of sound fruit could be secured. An illustration, in the case of field insects, may also be given where, by the adoption of a system of rotation, in which oats was made to alternate with corn, the owner of a large farm in Indiana made a

saving of \$10,000 per year, this amount representing the loss previously sustained annually from the corn root-worm. The cotton crop, which formerly in years of bad infestation by the leaf-worm, was estimated to be injured to the extent of \$30,000,000, is now comparatively free from such injury, owing to the general use of arsenicals.

Facts of like import could be adduced in regard to many other leading staples, but the foregoing are sufficient to emphasize the money value of intelligent action against insect enemies, which, with the present competition and diminishing prices, may represent the difference between a profit or a loss in agricultural operations.

INSECT 187
U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 19.

IMPORTANT INSECTICIDES:

DIRECTIONS FOR THEIR PREPARATION AND USE.

[REVISED EDITION.]

BY

C. L. MARLATT,
FIRST ASSISTANT ENTOMOLOGIST.

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Farmers' Bulletin No. 24. Hog Cholera and Swine Plague. Pp. 16. Issued December 12, 1895.

Farmers' Bulletin No. 25. Peanuts: Culture and Uses. Pp. 24. Issued February 9, 1895.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 17, 1895.

SIR: I have the honor to transmit herewith a revised edition of Farmers' Bulletin No. 19, a condensed account of the more important insecticides for farm and garden use, prepared under my direction by Mr. C. L. Marlatt, first assistant entomologist. As stated in my letter of transmittal to the first edition, circular No. 1, new series, of this division, contained information of this character, but this document is out of print, and since it was published some advance has been made in the matter of insecticides which necessitates the publication of some additional matter and some change in the methods of preparation of old and standard mixtures. The constant call for information of this character will warrant the publication of this bulletin in large edition.

Respectfully,

L. O. HOWARD, *Entomologist.*

Hon. CHAS. W. DABNEY, Jr.,
Acting Secretary of Agriculture.

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IMPORTANT INSECTICIDES: DIRECTIONS FOR THEIR PREPARATION AND USE.

Without going minutely into the field of remedies and preventives for insect depredators, it is proposed to give in this bulletin brief directions concerning a few of the insecticide agents having the widest range and attended with the greatest usefulness, economy, and ease of application. These are not covered by patent, and in general it is true that the patented articles are inferior, and many of the better of them are in fact merely more or less close imitations of the standard substances and compounds hereinafter described. Only such brief references to food and other habits of the insects covered will be included as are necessary to illustrate the principles underlying the use of the several insecticide agents recommended.

RELATION OF FOOD HABITS TO REMEDIES.

For the intelligent and practical employment of insecticides it is necessary to comprehend the nature and method of injury commonly due to insects. Omitting for the present purpose the many special cases of injury which necessitate peculiar methods of treatment, the great mass of the harm to growing plants from the attacks of insects falls under two principal heads based on distinct principles of food economy of insects, viz, whether they are biting (mandibulate) or sucking (haustellate), each group involving a special system of treatment.

INJURY FROM BITING INSECTS.

The biting or gnawing insects are those which actually masticate and swallow some portion of the solid substance of the plant, as the wood, bark, leaves, flowers or fruit. They include the majority of the injurious larvæ, many beetles, and the locusts.

For these insects direct poisons, such as the arsenicals, which may be safely applied to the leaves or other parts of the plant attacked, and which will be swallowed by the insect with its food, furnish the surest and simplest remedy, and should always be employed except where the parts treated are themselves to be shortly used for the food of other animals or of man.

The sucking insects are those which injure plants by the gradual extraction of the juices, either from the bark, leaves, or fruit, and include the plant-bugs, plant-lice, scale insects, thrips, and plant feeding mites. These insects possess, instead of biting jaws, sucking beaks or bristles, which are thrust down through the outer layers of the bark or leaves into the soft, succulent tissues beneath and used to extract the plant juices, with a resulting injury not so noticeable as in the first group, but not less serious.

For this class of insects the application of poisons, which penetrate little, if at all, into the plant cells, is of trifling value, and it is necessary to use substances which will act externally on the bodies of these insects, either as a caustic or to smother or stifle them by closing their breathing pores, or to fill the air about them with poisonous fumes. Of value also as repellants are various deterrent or obnoxious substances.

Wherever it is not desirable to use poisons for biting insects, some of the means just enumerated will often be available.

GROUPS SUBJECT TO SPECIAL TREATMENT.

The general grouping outlined above relates to the species which live and feed upon the exterior of plants for some portions or all of their lives, and includes the great majority of the injurious species. Certain insects, however, owing to peculiarities of habit, inaccessibility, or other causes, require special methods of treatment. Of these, two groups properly come within the scope of this bulletin: (1) Those working beneath the soil, or subterranean insects, such as the white grubs, root-maggots, root-lice, etc., and (2) insects affecting stored products, as various grain and flour pests.

Three other groups, which include species requiring very diverse methods of treatment, and therefore not coming within the limits of this bulletin, are (1) the internal feeders, such as wood, bark, and stem borers, leaf-miners, gall insects, and species living within fruits; (2) household pests, and (3) animal parasites.

The classification of insects outlined above, based on mode of nourishment and indicating groups amenable to similar remedial treatment, simply stated, is as follows:

- I. External feeders:
 - (a) Biting insects.
 - (b) Sucking insects.
- II. Internal feeders.
- III. Subterranean insects.
- IV. Insects affecting stored products.
- V. Household pests.
- VI. Animal parasites.

INSECTICIDES FOR EXTERNAL BITING INSECTS (FOOD POISONS).

THE ARSENICALS: PARIS GREEN AND LONDON PURPLE.

The arsenical compounds have supplanted all other substances for the insects falling under this heading. Two compounds are in common use, viz, Paris green and London purple.¹ The use of powdered white arsenic is not recommended, on account of its greater liability to scald foliage and because it is very apt to be mistaken for harmless substances. Of the first two mentioned, Paris green is the stronger insecticide, acting quickly, and is less liable to burn foliage. London purple has the advantage of cheapness, and, being more finely powdered, is kept more easily suspended in water. The former can be had in 14-pound or larger cans at 20 cents per pound, and the latter at 10 cents per pound by the barrel.

HOW TO APPLY ARSENICALS.

There are three principal methods of applying arsenicals. The wet method, which consists in using these poisons in water in the form of spray, is the standard means, secures uniform results at least expense, and is the only practical method of protecting fruit and shade trees. The dry application of these poisons in the form of a powder, which is dusted over plants, is more popular as a means against the cotton worm in the South, where the rapidity of treatment possible by this method, and its cheapness, give it a value against this insect, in the practical treatment of which prompt and economical action are the essentials. This method is also feasible for any low-growing crop, such as the potato. The third method consists in the use of the arsenicals in the form of poisoned baits, and is particularly available for such insects as cutworms, wireworms, and local invasions of locusts.

¹A third arsenical which promises well, arsenate of lead, has lately been experimented with by the Gypsy Moth Commission. While not urging that this insecticide has advantages over Paris green, it is held that it has the merit of showing on the leaves, indicating at once which have been sprayed, remains much more easily suspended in water, and may be used in large proportions without danger to foliage. It has recently been extensively tested at the Department, and a strength as great as 1 pound to 2 gallons of water has been used on tender foliage of the peach and Osage orange without injury. Good results have attended its use also against the imported elm leaf-beetle. The insecticide results were not better, however, than with Paris green; but for such sensitive foliage as that of the peach, or where no risk of scalding may be taken, I am inclined to believe that it will prove useful.

This insecticide is prepared by combining, approximately, 3 parts of arsenate of soda with 7 parts of acetate of lead. These substances unite chemically and form a fine, white powder which remains easily in suspension. As now used by the Commission, 10 pounds of the arsenate of lead are used with 150 gallons of water, 2 quarts of glucose being added to cause the insecticide to adhere longer to the leaves. Professor Fernald's experience and our own would indicate that from one-fourth to one-half this strength will answer for most larvæ—the larvæ of the gypsy moth proving to be unusually resistant to the action of poisons. The arsenate of lead costs the commission 7 cents a pound wholesale, and glucose \$16 a barrel.

The wet method.—Either Paris green or London purple may be used at the rate of 1 pound to 100 to 250 gallons of water, or 1 ounce to 6 to 15 gallons. The stronger mixtures are for such vigorous foliage as that of the potato, for the Colorado potato-beetle, and the greater dilutions for the more tender foliage of the peach or plum. An average of 1 pound to 150 gallons of water is a good strength for general purposes. The poison should be first made into a thin paste in a small quantity of water and powdered or quick lime added in amount equal to the poison used to take up the free arsenic and remove or lessen the danger of scalding. An excess of lime will do no injury. The poisons thus mixed should be strained into the spray tank or reservoir, care being taken that all the poison is pulverized and washed through the meshes of the strainer. The use of the lime is especially desirable in the case of the peach and plum, the foliage of which, particularly the former, is very tender and easily scalded. To the stronger foliage of the apple and most shade trees Paris green may be applied at the strength of 1 pound to 150 gallons of water without danger; with London purple it is always better to use the lime.

If it be desirable to apply a fungicide at the same time, as on the apple for the codling moth and the apple scab fungus, the Bordeaux mixture¹ may be used instead of water, adding the arsenical to it at the same rate per gallon as when water is used. The lime in this fungicide neutralizes any excess of free arsenic and makes it an excellent medium for the arsenical, removing, as it does, all liability of scalding the foliage and enabling an application of the arsenical, if necessary, eight or ten times as strong as it could be employed with water alone.

The arsenicals can not be safely used with most other fungicides, such as the sulphate of copper, eau celeste or iron chloride solution, the scalding effects of these in the mixture being greatly intensified.

The dry method.—The following description applies to the pole-and-bag duster commonly used against the cotton worm: A pole 5 to 8 feet

¹*Bordeaux mixture formula.*—Into a 50-gallon barrel pour 30 gallons of water, and suspend in it 6 pounds of bluestone in coarse sacking. Slack 4 pounds of fresh lime in another vessel, adding water slowly to obtain a creamy liquid, free from grit. When the bluestone is dissolved add the lime milk slowly with water enough to fill the barrel, stirring constantly.

With insufficient lime the mixture sometimes injures the foliage, and it should be tested with a solution obtained by dissolving an ounce of yellow prussiate of potash (potassium ferrocyanide) in one-half pint of water. If there be insufficient lime in the Bordeaux mixture the addition of a drop or two of this solution will cause a brownish-red color, and more lime should be added until no change takes place when the solution is dropped in. Use the Bordeaux mixture promptly, as it deteriorates on standing.

Stock solutions of both the bluestone and lime may be kept for any length of time. Make the stock bluestone by dissolving in water at the rate of 2 pounds to the gallon. The stock lime is slacked and kept as a thick paste. Cover both mixtures to prevent evaporation and keep the lime moist. For the 50-gallon formula add 3 gallons of the bluestone solution to 50 gallons of water, and introduce the stock lime slowly until there is no reaction with the testing solution.—B. T. G.

long and about 2 inches in diameter is taken, and a three-fourths inch hole bored through it within 6 inches of either end. Near each end is securely tacked a bag of "8-ounce osnaburg cloth," 1 foot wide and 18 inches to 2 feet long, so that the powdered poison may be introduced into the bags with a funnel through the holes at the ends of the pole. The bags are filled with undiluted Paris green, which is generally preferred to London purple on account of its quicker action, and the apparatus is carried, on horse or mule back, through the cotton fields, dusting two or four rows at once. The shaking induced by the motion of the animal going at a brisk walk or at a trot is sufficient to dust the plants thoroughly, or the pole may be jarred by hand. The application is preferably made in early morning or late evening when the dew is on, to cause the poison to adhere better to the foliage.

From 1 to 2 pounds are required to the acre, and from 10 to 20 acres are covered in a day. The occurrence of heavy rains may necessitate a second application, but frequently one will suffice. This simple apparatus, on account of its effectiveness and cheapness, is employed throughout the cotton belt to the general exclusion of more complicated and expensive machinery.

With the patented air-blast machines for the dry distribution of poisons, arsenicals are diluted with 10 parts of flour, lime, or ground gypsum, and from 60 to 75 acres may be covered in a day by using relays of men and teams. Greater uniformity is secured with these machines in distribution of the poisons, but their cost (from \$30 to \$60) prevents their general use.

The planter should have a good supply of poison on hand and apparatus for its application prepared in advance, since when the worm puts in an appearance its progress is very rapid, and a delay of a single day may result in material damage to the crop.

If small garden patches are dusted with poison by this or similar means from bags or with hand powder bellows, it is advisable always to dilute the poison with 10 parts of flour, or preferably lime, and for application to vegetables which may soon be used for food, as the cabbage, 1 ounce of the poison should be mixed with 6 pounds of flour or 10 of lime, and dusted merely enough to show evenly over the surface.

As poisoned bait.—It is not always advisable or effective to apply arsenicals directly to the plants, and this is particularly true in the case of the attacks of the grasshopper and of the various cutworms and wireworms. In such cases the use of poisoned bait has proven very satisfactory.

For locusts, take 1 part by weight of white arsenic, 1 of sugar, and 6 of bran, to which add water to make a wet mash. Place a teaspoonful of this at the base of each tree or vine, or apply a line of baits just ahead of the advancing army of grasshoppers, placing a tablespoonful of the mash every 6 or 8 feet, and following up with another line behind the first.

For baiting cutworms and wireworms, distribute poisoned green, succulent vegetation, such as freshly cut clover, in small bunches about in the infested fields. Dip the bait in a very strong arsenical solution, and protect from drying by covering with boards or stones. Renew the bait as often as it becomes dry, or every three to five days. The bran-arsenic bait will also answer for cutworms.

TIME TO SPRAY FOR BITING INSECTS.

For the codling moth, the apple and pear should receive the first application very soon after the blossoms fall, which is also the time for the second treatment of the scab fungus; the second spraying should be given one or two weeks later, just before the fruit turns down on the stem or when it is from one-fourth to one-half inch in diameter. The first spraying reaches the eggs laid by the moth in the flower end of the fruit shortly after the falling of the blossoms, and the second the later egg-laying by the more belated moths, when the first coating of poison will probably have been washed off by rains. The young larva, eating its way from without into the fruit, gets enough of the poison to destroy it. This treatment reaches at the same time a large number of leaf-feeding enemies of these fruit trees.

For the *Curculio* of the stone fruits, plum, cherry, peach, etc., two or three applications should be made; the first before the trees bloom or as soon as the foliage is well started, the second at the time of the exposure of the young fruit by the falling of the blossoms, and perhaps a third a week later, particularly if rains have intervened after the last treatment. The poison here acts to destroy the parent *Curculio* instead of the young larvæ, which, hatching from eggs placed beneath the skin of the fruit, are not affected by the poison on the outside. The adult *Curculio*, however, as soon as it comes from its hibernation feeds on the foliage before the trees bloom, and later on the young fruit also, and is destroyed by the arsenical before its eggs are deposited.

For leaf feeding insects in general, such as the Colorado potato beetle, blister beetles, elm leaf-beetle, maple worm, etc., the application should be made at the earliest indication of injury and repeated as often as necessary. Fruit trees should never be sprayed when in bloom on account of the liability of poisoning honey bees or other insects useful as cross fertilizers.

CARE IN USE OF ARSENICALS.

It must be remembered that these arsenicals are very poisonous, and should be so labeled. If ordinary precautions are taken there is no danger to man or team attending their application, and the wetting of either, which can not always be avoided, is not at all dangerous, on account of the great dilution of the mixture, and no ill results whatever have resulted from this source.

The poison disappears from the plants almost completely within

twenty to twenty-five days, and even if the plants were consumed shortly after the application an impossible quantity would have to be eaten to get a poisonous dose. To illustrate, in the case of the apple, if the entire fruit were eaten, core and all, it would take several barrels at a single sitting to make a poisonous dose (Riley), and with the cabbage, dusted as recommended above, 28 heads would have to be eaten at one meal to reach this result (Gillette). It is preferable, however, to use other insecticides in the case of vegetables soon to be eaten, and thus avoid all appearance of danger.

INSECTICIDES FOR EXTERNAL SUCKING INSECTS (CONTACT POISONS).

The simple remedies for this class of insects, such as soap and lye washes, tobacco decoction, etc., are frequently of the greatest service, but need no special explanation. The whale oil is the most valuable of the soaps, and at the rate of 1 pound to 4 gallons of water, dissolved by heating, kills most soft-bodied insects, and at 1 to 2 pounds to the gallon is an effective winter wash for scale insects, even the very resistant San José scale succumbing to the latter strength. The insect powders (Pyrethrum or Buhach) are effective, but too expensive for any but limited or indoor use. The following are standard remedies for this group of insects: Kerosene emulsions, resin washes, hydrocyanic acid gas, and vapor of bisulphide of carbon.

THE KEROSENE WASHES.

The kerosene and soap emulsion formula.

Kerosene.....	gallons..	2
Whale-oil soap (or 1 quart soft soap)	pound..	$\frac{1}{2}$
Water	gallon..	1

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct-discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, the emulsion will keep indefinitely, and should be diluted only as wanted for use.

The use of whale oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, and does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft soap answers very well, and 1 quart of it may be taken in lieu of the hard soaps.

In limestone regions or where the water is very hard some of the soap will combine with the lime or magnesia in the water and more or less of the oil will be freed, especially when the emulsion is diluted. Before using, such water should be broken with lye, or rain water employed; but better than either, follow the milk emulsion formula, with which the character of the water, whether hard or soft, does not affect the result.

The kerosene and milk emulsion formula.

Kerosene	gallons.. 2
Milk (sour)	gallon.. 1

Heating is unnecessary in making the milk emulsion, which otherwise is churned, as in the former case. The change from a watery liquid to a thick buttery consistency, much thicker than with the soap, takes place very suddenly after three to five minutes' agitation. With sweet milk difficulty will frequently be experienced, and if the emulsion does not result in five minutes, the addition of a little vinegar will induce prompt action. It is better to prepare the milk emulsion from time to time for immediate use, unless it can be stored in quantity in air-tight jars, otherwise it will ferment and spoil after a week or two.

How to use the emulsions.—During the growing period of summer, for most plant-lice and other soft-bodied insects, dilute the emulsion with from 15 to 20 parts of water; for the red spider and other plant mites the same, with the addition of 1 ounce of powdered sulphur to the gallon; for scale insects, the larger plant bugs, larva, and beetles, dilute with from 7 to 9 parts water; apply with spray pump.

For winter applications to the trunks and larger limbs of trees, in the dormant and leafless condition, to destroy scale insects, stronger mixtures may be used even to the pure emulsion, which latter can not be sprayed successfully but may be applied with brush or sponge. Diluted with one or more parts of water it may be applied in spray without difficulty. The use of the pure emulsion is heroic treatment and only advisable in cases of excessive infestation, and in general it is much better and safer to defer the treatment until the young scales hatch in the spring, when the nine-times diluted wash may be used with more certain results and without danger to plants. The winter treatment should be followed by a use of the spring wash to destroy any young which may come from female scales escaping the stronger mixture.

Pure kerosene.—The pure oil may be applied as a winter wash to the older parts of plants either in a spray or with a sponge, using the least possible quantity. Its use is not advised save in exceptionally bad cases of infestation and during the dormant period, and should never be attempted after the first sign of spring growth appears.

In many cases plant-bugs and beetles may be jarred into cloths saturated with kerosene or into pans with water and oil and destroyed, where it would be unsafe or inadvisable to spray the plants themselves.

As a remedy against the mosquito, kerosene has proven very effective

(Howard). It is employed to destroy the larvæ of the mosquitoes in their favorite breeding places in small pools, still ponds, or stagnant water, and where such bodies of water are not sources of drinking supply or of value for their fish, especially in the case of temporary pools from rains, which frequently breed very disagreeable local swarms, the use of oil is strongly recommended. The kerosene is applied at the rate of 1 ounce to 15 square feet of water surface, and forms a uniform film over the surface and destroys all forms of aquatic insect life, including the larvæ of the mosquito and also the adult females coming to the water to deposit their eggs. The application retains its efficiency for several weeks, even with the occurrence of heavy rains.

THE RESIN WASH.

This wash has proved of greatest value in California, particularly against red scale (*Aspidiotus aurantii*), and will be of use in all similar climates where the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and where, owing to the warmth, the multiplication of the scale insects continues almost without interruption throughout the year. Where rains are liable to occur at short intervals, and in the Northern States, the quicker-acting and stronger kerosene washes are preferable. The resin wash acts by contact, having a certain caustic effect, but principally by forming an impervious, smothering coating over the scale insects. The application may be more liberal than with the kerosene washes, the object being to thoroughly wet the bark.

The wash may be made as follows:

Resin.....	pounds..	20
Crude caustic soda (78 per cent)	do.....	5
Fish oil.....	pints..	2½
Water to make	gallons..	100

Ordinary commercial resin is used, and the caustic soda is that put up for soap establishments in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (98 per cent) used—3½ pounds of the latter being the equivalent of 5 pounds of the former. Place these substances with the oil in a kettle with water to cover them to a depth of 3 or 4 inches. Boil for one or two hours, making occasional additions of water, or until the compound resembles very strong black coffee. Dilute to one-third the final bulk with hot water, or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed the mixture should be perfectly fluid, without sediment, and should any appear in the stock mixture reheating should be resorted to.

As a winter wash for scale insects, and particularly for the more resistant San José scale (*Aspidiotus perniciosus*), stronger washes are necessary. In southern California, for this latter insect, the equivalent of a dilution one-third less, or to 66⅔ gallons instead of 100, has given

very good satisfaction. In Maryland, with this insect, it has proved necessary to use the wash at 6 times the summer strength to destroy all of the well-protected hibernating scales; and with other scale insects much stronger mixtures than those used in California have, in the east, proved ineffectual. For regions, therefore, with moderately severe winters, the use of the resin wash to destroy hibernating scale insects seems inadvisable.

TIME TO SPRAY FOR SUCKING INSECTS.

For the larger plant bugs and the aphides, or active plant lice, and all other sucking insects which are present on the plants injuriously for comparatively brief periods, or at most during summer only, the treatment should be immediate, and if in the form of spray on the plants, at a strength which will not injure growing vegetation.

For scale insects and some others, as the pear *Psylla*, which hibernate on the plants, two or more strengths are advised with most of the liquid insecticides recommended, the weaker for summer applications and the more concentrated as winter washes. The summer washes for scale insects are most effective against the young, and treatment should begin with the first appearance of the larvæ of the spring or any of the later broods, and should be followed at intervals of seven days with two or three additional applications. The first brood, for the majority of species in temperate regions, will appear during the first three weeks in May. Examination from time to time with a hand lens will enable one to determine when the young of any brood appear.

The winter washes may be used whenever summer treatment can not be successfully carried out, and are particularly advantageous in the case of deciduous plants with dense foliage which renders a thorough wetting difficult in summer, or with scale insects which are so irregular in the time of disclosing their young that many summer treatments would be necessary to secure anywhere near complete extermination. In the winter also, with deciduous trees, very much less liquid is required, and the spraying may be much more expeditiously and thoroughly done. In the case of badly infested trees, a vigorous pruning is advisable as a preliminary to treatment.

All of the washes mentioned are excellent as summer remedies. As winter washes for temperate regions the kerosene mixtures and whale-oil soap solutions, particularly the latter, have so far given the best results. These stronger mixtures may be applied at any time during the dormant period of vegetation, and, with deciduous trees, preferably immediately after the falling of the foliage. In the growing season any of these stronger washes would cause the loss of foliage and fruit, and the more concentrated probably the death of the plant.

THE GAS TREATMENT.

Hydrocyanic Acid Gas.

The hydrocyanic acid gas treatment of scale-infested trees, until recently exclusively confined to California, has, within the last year, been introduced in the East by the Department to combat the San José

seale. Briefly, it consists in inclosing a tree (or nursery stock in greater or less quantities at once) with a tent and filling the latter with the poisonous fumes generated with potassium cyanide and sulphuric acid.

The outfit.—The tents are made of blue or brown drilling or 8-ounce duck, and painted or oiled with linseed oil to make them as near airtight as possible. A very convenient form of tent is made in the shape of a large hexagonal sheet, which, thrown over a tree, will touch the ground on all sides. These sheets or tents are placed over the trees by hand or with poles in case of small trees, but with trees over 10 feet high some sort of a tripod or derrick is used. The outfit for medium-sized trees—tent and derrick—will cost from \$15 to \$25. A tent for trees 26 feet tall by 60 feet in circumference costs as much as \$60.

The chemicals.—Commercial fused potassium cyanide, 58 per cent purity (costing in bulk 40 cents per pound), commercial sulphuric acid (at $3\frac{1}{2}$ cents per pound), and water are used in generating the gas, the proportions being 1 ounce by weight of the cyanide, slightly more than 1 fluid ounce of the acid, and 3 fluid ounces of water to every 150 cubic feet of space inclosed.

The method.—The generator, which may be any glazed earthenware vessel of 1 or 2 gallons' capacity, is placed within the tent under the tree and the water, acid and cyanide, the latter broken up, put in in the order named, after which the operator withdraws from the tent. The tent is allowed to remain on the tree for one-half hour for large trees or fifteen minutes for small ones. The treatment is best made on cloudy days, early in the morning, late in the evening, or at night. Bright, hot sunlight is liable to cause injury to the foliage, which, however, may be largely avoided by using tents of dark material or painted black.

Three or four men can operate six tents at once, and the expense under such conditions, not counting the cost of the outfit, need not be more than 10 cents per tree. One outfit of tents and hoisting apparatus will answer for an entire community or county.

Bisulphide of Carbon Vapor.

In line with the use of hydrocyanic acid gas is the employment of the vapor of bisulphide of carbon to destroy insects on low-growing plants, such as the lice on melon and squash vines. The treatment, as successfully practiced by Professors Garman and Smith, consists in covering the young vines with small tight boxes 12 to 18 inches in diameter, of either wood or paper, and introducing under each box a saucer containing one or two teaspoonfuls (1 or 2 drams) of the very volatile liquid, bisulphide of carbon. The vines of older plants may be wrapped about the hill and gathered in under larger boxes or tubs, and a greater, but proportional, amount of bisulphide used. The covering should be left over the plants for three-quarters of an hour to an hour, and with 50 to 100 boxes a field may be treated with comparative rapidity.

DUSTING AND SPRAYING APPARATUS.

For the application of powders the dusting bags already described are very satisfactory, or for garden work some of the small powder bellows and blowers are excellent. The best of these cost about \$2 each and are on the market in many styles.

Better apparatus is required for the wet applications where successful results require the breaking up of the liquid into a fine mist-like spray. The essential features of such an apparatus are a force pump, several yards of one-half inch cloth-reinforced hose with bamboo hoisting rod, and a spray tip. The size of the apparatus will depend on the amount of vegetation to be treated. For limited garden work and for the treatment of low plants the knapsack pumps or the small bucket force-pumps are suitable, the former costing about \$14 and the latter from \$6 to \$9.

Ready fitted pumps, knapsack and others, for the application of insecticides, are now made by all the leading pump manufacturers of this country and also large reservoirs with pump attached for extended orchard operations, the price of the latter ranging from \$25 to \$75.

The cost of a spraying outfit for orchard work may be greatly reduced by combining a suitable pump and fixtures with a home-constructed tank or barrel to be mounted on a cart or wagon. A spray-tank having a capacity of about 150 gallons is a very satisfactory size, and may be conveniently made 4 feet long, by 2½ wide by 2 deep, inside measurements. It should be carefully constructed, so as to be water tight, and should be strengthened by four iron bolts or rods across the ends, one each at the top and bottom. A good double-acting force-pump may be obtained from any of the leading pump manufacturers at a cost of from \$10 to \$20, depending upon whether of iron or brass, and the nature of its fittings. For use in a very large orchard or in city parks, it may be advisable to construct the tank of twice the capacity mentioned to expedite the spraying and to avoid the more frequent refillings necessary with the smaller tank.

The more economical spray tips in the amount of liquid required are the different styles of cyclone nozzles, the best form of which is known to the market generally as the Vermorel nozzle. These are manufactured by the leading spray pump companies. Other good nozzles are also on the market. The common garden spraying and hose nozzles are much too coarse for satisfactory work, and are wasteful of the liquid.

A prime essential in spraying, especially where the large reservoirs are employed, is to keep the liquid constantly agitated to prevent the settling of the poison to the bottom of the tank. This may be accomplished by constant stirring with a paddle, by shaking, but preferably by throwing a stream of the liquid back into the tank. Many of the larger pumps are now constructed with two discharge orifices with this latter object in view, and the use of such is recommended.

For fruit trees of average size, or, if apple, such as would produce from 10 to 15 bushels of fruit, from 3 to 7 gallons of spray are necessary to thoroughly wet each tree. For smaller trees, such as plum and cherry, 1 gallon to the tree will be sufficient. If an average of 5 gallons to the tree be taken for an apple orchard of 1,000 trees 5,000 gallons of spray would be required. About 33 pounds of paris green or london purple would be needed for one spraying, if used at the rate of 1 pound to 150 gallons of water, and for the two applications ordinarily recommended, 66 pounds. This, for the paris green, at 20 cents a pound, would amount to \$13.20, and the london purple, at 10 cents a pound, to \$6.60, or a little over 1 cent a tree for the former and one-half a cent for the latter.

In spraying orchard trees, it will be found convenient in going between the rows to spray on either side, half of each tree in the row at a time and finish on the return, rather than attempt to spray all sides of one tree before taking up another.

The object in spraying is to coat every leaf and part of the plant as lightly as feasible with thoroughness, and to avoid waste in doing this a mist spray is essential. The application to any part should stop when water begins to drip from the leaves. A light rain will not remove the poison, but a dashing one will probably necessitate a renewal of the application.

REMEDIES FOR SUBTERRANEAN INSECTS.

Almost entire dependence is placed on the caustic washes, or those that act externally, for insects living beneath the soil on the roots of plants, including both sucking and biting insects, prominent among which are the white grubs, maggots in roots of cabbage, radishes, onions, etc., cutworms, wireworms, apple and peach root-lice, the grape phylloxera, and many others.

The insecticide must be one that will go into solution and be carried down by water. Of this sort are the kerosene emulsions and resin wash—the former preferable—the potash fertilizers, muriate and kainit, and bisulphide of carbon. Submersion, wherever the practice of irrigation or the natural conditions make it feasible, has also proven of the greatest service against the phylloxera.

Kerosene emulsion and resin wash.—Either the kerosene and soap emulsion or the resin wash, the former diluted 15 times and the latter at the strength of the winter mixture, are used to saturate the soil about the affected plants and either left to be carried down by the action of rains or washed down to greater depths by subsequent waterings.

For the grape phylloxera or the root-louse of the peach or apple, make excavations 2 or 3 feet in diameter and 6 inches deep about the base of the plant, and pour in 5 gallons of the wash. If not a rainy

season, a few hours later wash down with 5 gallons of water and repeat with a like amount the day following. It is better, however, to make this treatment in the spring, when the more frequent rains will take the place of the waterings.

For root maggots enough of the wash is put along at the base of the plant to wet the soil to a depth of 1 to 2 inches, preferably following after an hour with a like amount of water.

For white grubs in strawberry beds or in lawns the surface should be wetted with kerosene emulsion to a depth of 2 or 3 inches, following with copious waterings to be repeated for two or three days. The larvæ go to deeper and deeper levels and eventually die.

Potash fertilizers.—For white grubs, wireworms, cutworms, corn root-worms, and like insects, on the authority of Prof. J. B. Smith, either the kainit or muriate of potash, the former better, are broadcasted in fertilizing quantities, preferable before or during a rain so that the material is dissolved and carried into the soil at once. These not only act to destroy the larvæ in the soil, but are deterrents, and truck lands constantly fertilized by these substances are noticeably free from attacks of insects. This, in a measure, results from the increased vigor and greater resistant power of the plant, which, of itself, more than compensates for the cost of the treatment. The value of these fertilizers against the wireworms is, however, questioned by Prof. J. H. Comstock.

For the root-louse of peach and apple work the fertilizer into the general surface of the soil about the trees, or put it in a trench about the tree 2 feet distant from the trunk.

For cabbage and onion maggots apply in little trenches along the roots at the rate of 300 to 500 pounds to the acre, and cover with soil.

These fertilizers (and the nitrate of soda is nearly as good) are also destructive to the various insects which enter the soil for hibernation or to undergo transformation.

Bisulphide of carbon.—This is the great French remedy for the phylloxera, 150,000 acres being now subjected to treatment with it, and applies equally well to all other root-inhabiting lice. The treatment is made at any season except the period of ripening of the fruit, and consists in making holes about the vines 1 foot to 16 inches deep and pouring into each about one-half ounce of bisulphide, and closing the hole with the foot. These injections are made about $1\frac{1}{2}$ feet apart, and not closer to the vines than 1 foot. It is better to make a large number of small doses than a few large ones. Hand injectors and injecting plows are employed in France to put the bisulphide into the soil about the vines, but a short stick or iron bar may be made to take the place of these injectors for limited tracts.

For root maggots a teaspoonful is poured into a hole at the base of the plant, covering as above.

For ant nests an ounce of the substance is poured into each of sev-

eral holes made in the space occupied by the ants, the openings being then closed, or the action is made more rapid by covering with a wet blanket for ten minutes and then exploding the vapor at the mouth of the holes with a torch, the explosion driving the fumes more thoroughly through the soil.

Submersion.—This very successful means against the phylloxera is now practiced over some 75,000 acres of vineyards in France which were once destroyed by the grape root-louse, and the production and quality of fruit has been fully restored. In this country it will be particularly available in California and in all arid districts where irrigation is practiced, otherwise it will be too expensive to be profitable. The best results are secured in soils in which the water will penetrate rather slowly, or from 6 to 18 inches in twenty-four hours; in loose, sandy soils it is impracticable on account of the great amount of water required. Submersion consists in keeping the soil of the vineyard flooded for from eight to twenty days after the fruit has been gathered and active growth of the vine ceased, or during September or October, but while the phylloxera is still in active development. Early in September eight to ten days will suffice; in October, fifteen to twenty days, and during the winter, as was formerly practiced, forty to sixty days. Supplementing the short fall submergence a liberal July irrigation, amounting to a forty-eight-hour flooding, is customary to reach any individuals surviving the fall treatment, and which in midsummer are very susceptible to the action of water.

To facilitate the operation vineyards are commonly divided by embankments of earth into square or rectangular plots, the former for level and the latter for sloping ground, the retaining walls being protected by coverings of reed grass, etc., during the first year, or until they may be seeded to some forage plant.

This treatment will destroy many other root-attacking insects or those hibernating beneath the soil, and, in fact, is a very ancient practice in certain oriental countries bordering the Black Sea and the Grecian Archipelago.

REMEDIES FOR INSECTS AFFECTING GRAIN AND OTHER STORED PRODUCTS.

The chief loss in this direction from insects is to grains in farmers' bins, or grain or grain products in stores, mills, and elevators, although in the warmer latitudes much of the injury results from infestation in the field between the ripening of the grain and its storage in bins or granaries. Fortunately, the several important grain insects are amenable to like treatment. Aside from various important preventive considerations, such as, in the South, prompt threshing of grain after harvesting, the thorough cleansing of bins before refilling, constant sweeping, removal of waste harboring insects from all parts of granaries and mills, and care to prevent the introduction of "weeviled" grain,

there are three valuable remedial measures, viz, agitation of the grain, heating, and dosing with bisulphide of carbon.

The value of agitating or handling grain is well known, and whenever, as in elevators, grain can be transferred or poured from one bin into another grain pests are not likely to trouble. The benefit will depend upon the frequency and thoroughness of the agitation, and in France machines for shaking the grain violently have been used with success. Winnowing weeviled grain is also an excellent preliminary treatment.

Raising the temperature of the grain in closed retorts or revolving cylinders to 130° to 150° F. will kill the inclosed insects if continued for from three to five hours, but is apt to injure the germ, and is not advised in case of seed stock. The simplest, cheapest, and most effectual remedy is the use of bisulphide of carbon.

BISULPHIDE OF CARBON.

This is a colorless liquid with very offensive odor, which, however, passes off completely in a short time. It readily volatilizes and the vapor, which is very deadly to insect life, is heavier than air and settles and fills any compartment or bin in the top of which the liquid is placed. It may be distributed in shallow dishes or tins or in saturated waste on the top of grain in bins, and the gas will settle and permeate throughout the mass of the grain. In large bins, to hasten and equalize the operation, it is well to put a quantity of the bisulphide in the center of the grain by thrusting in balls of cotton or waste tied to a stick and saturated with the liquid, or by means of a gas pipe loosely plugged at one end, down which the liquid may be poured and the plug then loosened with a rod. In moderately tight bins no further precaution than to close them well need be taken, but in open bins it will be necessary to cover them over with a blanket to prevent the too rapid dissipation of the vapor. The bins or buildings should be kept closed from 24 to 36 hours, after which a thorough airing should be given them.

Limited quantities at a time may often be advantageously subjected to treatment in small bins before being placed for long storage in large masses, and especially whenever there is danger of introducing infested grain.

The bisulphide is applied at the rate of 1 pound to the ton of grain, or a pound to a cubic space 10 feet on a side.

In the case of mills, elevators, or larger granaries the application may be best made on Saturday night, leaving the building closed over Sunday, with a watchman without to see that no one enters and to guard against fire. The bisulphide should be first distributed in the lower story, working upward to avoid the settling vapor, using the substance very freely, in waste or dishes, at all points of infestation and over bins throughout the building.

This insecticide may also be used in other stored products, as pease, beans, etc., and very satisfactorily where the infested material can be inclosed in a tight can, chest or closet for treatment.

The bisulphide costs, in 50-pound cans, 10 cents per pound, and in small quantities, of druggists, 25 to 35 cents per pound.

Caution.—The bisulphide may be more freely employed with milling grain than that intended for seeding, since used excessively it is liable to injure the germ. It must always be remembered that the vapor is highly inflammable and explosive, and that no fire or lighted cigars, etc., should be in the building during its use. If obtained in large quantities it should be kept in tightly closed vessels and away from fire, preferably in a small outbuilding.

CONTROL OF INSECTS BY CULTURAL METHODS.

It is much easier to ward off an attack of insects or to make conditions unfavorable for their multiplication than to destroy them after they are once in possession; and in controlling them, methods and systems of farm and orchard culture have long been recognized as of the greatest value—more so even than the employment of insecticides, which, in most cases, can only stop an injury already begun. Insects thrive on neglect, multiply best in land seldom or never cultivated, and winter over in rubbish, prunings, or the undisturbed soil about their food plants, and become, under these conditions, more numerous every year. It is a fact of common observation that it is the neglected farm, vineyard, or orchard filled with weeds or wild growth which is certain to be stocked with all the principal insect enemies; and, on the other hand, thorough and constant culture, with the removal and burning of prunings, stubble, and other waste, the collection and destruction of fallen and diseased fruit, and the practice, where possible, of fall plowing to disturb the hibernating quarters of field insects, will almost certainly be accompanied by comparative immunity from insect pests.

The vigor and healthfulness of plant growth has also much to do with freedom from insect injury, such plants seeming to have a native power of resistance which renders them, in a measure, distasteful to most insects, or at least able to throw off or withstand their attacks. A plant already weakened, however, or of lessened vitality from any cause, seems to be especially sought after, is almost sure to be the first affected, and furnishes a starting point for general infestation. Anything, therefore, which aids good culture in keeping plants strong and vigorous, such as the judicious use of fertilizers, will materially assist in preventing injury.

To the constant cropping of large areas of land year after year to the same staple is largely due the excessive loss from insects in this country as compared with European countries, because this practice furnishes the best possible conditions for the multiplication of the

enemies of such crops. A most valuable cultural means, therefore, is a system of rotation of crops which will prevent the gradual yearly increase of the enemies of any particular staple by the substitution every year or two of other cultures not subject to the attacks of the insect enemies of the first.

With such insects as the Hessian fly, the squash borers, and many others which have regular times of appearance, much can be done, also, by the planting of early or late varieties, or by deferring seeding so as to avoid the periods of excessive danger. Wherever possible, varieties should be selected which experience has shown to be resistant to insect attack. Familiar illustrations of such resistant varieties in all classes of cultivated plants will occur to every practical man, and a better instance of the benefit to be derived from taking advantage of this knowledge can not be given than the almost universal adoption of resistant American vines as stocks for the regeneration of the vineyards of France destroyed by the phylloxera.

In the case of stored grain pests, particularly the Angoumois moth, or so-called fly weevil, the chief danger in the South is while the grain is standing in shock or stack, after harvesting, during which period the insects have easy access to it. This source of infestation may be avoided by promptly threshing grain after harvesting and storing it in bulk. This will prevent the injury of more than the surface layer, as the insects are not likely to penetrate deeply into the mass of the grain.

These general notes are by no means new, but their importance justifies their repetition, as indicating the best preventive measures in connection with the remedial ones already given.

THE PROFIT IN REMEDIAL MEASURES.

The overwhelming experience of the past dozen years makes it almost unnecessary to urge, on the ground of pecuniary returns, the adoption of the measures recommended in the foregoing pages against insects. To emphasize the value of such practice, it is only necessary to call attention to the fact that the loss to orchard, garden, and farm crops frequently amounts to from 15 to 75 per cent of the entire product, and innumerable instances could be pointed out where such loss has been sustained year after year, while now, by the adoption of remedial measures, large yields are regularly secured with an insignificant expenditure for treatment. It has been established that in the case of the apple crop, spraying will protect from 50 to 75 per cent of the fruit which would otherwise be wormy, and that in actual marketing experience the price has been enhanced from \$1 to \$2.50 per barrel, and this at a cost of only about 10 cents per tree for labor and material.

In the case of one orchard in Virginia, only one-third of which was sprayed, the result was an increase in the yield of sound fruit in the portion treated of nearly 50 per cent, and an increase of the value of this fruit over the rest of 100 per cent. The loss from not having treated

the other two-thirds was estimated at \$2,500. The saving to the plum crop and other small fruits frequently amounts to the securing of a perfect crop where otherwise no yield whatever of sound fruit could be secured.

An illustration, in the case of field insects, may also be given where, by the adoption of a system of rotation, in which oats were made to alternate with corn, the owner of a large farm in Indiana made a saving of \$10,000 per year, this amount representing the loss previously sustained annually from the corn root-worm. The cotton crop, which formerly in years of bad infestation by the leaf-worm was estimated to be injured to the extent of \$30,000,000, is now comparatively free from such injury, owing to the general use of arsenicals.

Facts of like import could be adduced in regard to many other leading staples, but the foregoing are sufficient to emphasize the money value of intelligent action against insect enemies, which, with the present competition and diminishing prices, may represent the difference between a profit or a loss in agricultural operations.



FARMERS' BULLETIN NO. 19,

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 19.

IMPORTANT INSECTICIDES:

DIRECTIONS FOR THEIR PREPARATION AND USE.

[THIRD REVISED EDITION.]

BY

C. L. MARLATT,

FIRST ASSISTANT ENTOMOLOGIST.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., July 15, 1897.

SIR: I have the honor to transmit herewith a third revised edition of Farmer's Bulletin No. 19, a condensed account of the more important insecticides for farm and garden use, prepared under my direction by Mr. C. L. Marlatt, first assistant entomologist. During the three years since the publication of the last edition some advance has been made in the subject of insecticides which necessitates the publication of some additional matter and some change in the methods of preparation of old and standard mixtures. The constant call for information of this character will warrant the publication of this bulletin in large edition.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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IMPORTANT INSECTICIDES: DIRECTIONS FOR THEIR PREPARATION AND USE.

Without going minutely into the field of remedies and preventives for insect depredators, it is proposed to give in this bulletin brief directions concerning a few of the insecticide agents having the widest range and attended with the greatest usefulness, economy, and ease of application. These are not covered by patent, and in general it is true that the patented articles are inferior, and many of the better of them are in fact merely more or less close imitations of the standard substances and compounds hereinafter described. Only such brief references to food and other habits of the insects covered will be included as are necessary to illustrate the principles underlying the use of the several insecticide agents recommended.

RELATION OF FOOD HABITS TO REMEDIES.

For the intelligent and practical employment of insecticides it is necessary to comprehend the nature and method of injury commonly due to insects. Omitting for the present purpose the many special cases of injury which necessitate peculiar methods of treatment, the great mass of the harm to growing plants from the attacks of insects falls under two principal heads based on distinct principles of food economy of insects, viz, whether they are biting (mandibulate) or sucking (haustellate), each group involving a special system of treatment.

INJURY FROM BITING INSECTS.

The biting or gnawing insects are those which actually masticate and swallow some portion of the solid substance of the plant, as the wood, bark, leaves, flowers, or fruit. They include the majority of the injurious larvæ, many beetles, and the locusts.

For these insects direct poisons, such as the arsenicals, which may be safely applied to the leaves or other parts of the plant attacked, and which will be swallowed by the insect with its food, furnish the surest and simplest remedy, and should always be employed, except where the parts treated are themselves to be shortly used for the food of other animals or of man.

INJURY FROM SUCKING INSECTS.

The sucking insects are those which injure plants by the gradual extraction of the juices, either from the bark, leaves, or fruit, and include the plant-bugs, plant-lice, scale insects, thrips, and plant-feeding mites. These insects possess, instead of biting jaws, sucking beaks or bristles, which are thrust down through the outer layers of the bark or leaves into the soft, succulent tissues beneath and used to extract the plant juices, with a resulting injury not so noticeable as in the first group, but not less serious.

For this class of insects the application of poisons, which penetrate little, if at all, into the plant cells, is of trifling value, and it is necessary to use substances which will act externally on the bodies of these insects, either as a caustic or to smother or stifle them by closing their breathing pores, or to fill the air about them with poisonous fumes. Of value also as repellants are various deterrent or obnoxious substances.

Wherever it is not desirable to use poisons for biting insects, some of the means just enumerated will often be available.

GROUPS SUBJECT TO SPECIAL TREATMENT.

The general grouping outlined above relates to the species which live and feed upon the exterior of plants for some portion or all of their lives, and includes the great majority of the injurious species. Certain insects, however, owing to peculiarities of habit, inaccessibility, or other causes, require special methods of treatment. Of these, two groups properly come within the scope of this bulletin: (1) Those working beneath the soil, or subterranean insects, such as the white grubs, root maggots, root-lice, etc., and (2) insects affecting stored products, as various grain and flour pests.

Three other groups, which include species requiring very diverse methods of treatment, and therefore not coming within the limits of this bulletin, are (1) the internal feeders, such as wood, bark, and stem borers, leaf-miners, gall insects, and species living within fruits; (2) household pests, and (3) animal parasites.

The classification of insects outlined above, based on mode of nourishment and indicating groups amenable to similar remedial treatment, simply stated, is as follows:

- I. External feeders:
 - (a) Biting insects.
 - (b) Sucking insects.
- II. Internal feeders.
- III. Subterranean insects.
- IV. Insects affecting stored products.
- V. Household pests.
- VI. Animal parasites.

INSECTICIDES FOR EXTERNAL BITING INSECTS (FOOD POISONS).

THE ARSENICALS: PARIS GREEN, SCHEEL'S GREEN, ARSENITE OF LEAD, AND LONDON PURPLE.

The arsenical compounds have supplanted, practically, all other substances for the insects falling under this heading.¹ The two arsenicals in most common use, and obtainable everywhere, are Paris green and London purple. The other two arsenicals mentioned, viz, Scheele's green and arsenite of lead, are less known and not so easily obtainable, but in some respects are better than the first-mentioned poisons, as will be shown later. The use of powdered white arsenic is not recommended on account of its great liability to scald foliage as well as for the fact that it is apt to be mistaken for harmless substances. The arsenicals mentioned have the following characteristics:

Paris green is a definite chemical compound of arsenic, copper, and acetic acid (known as the aceto-arsenite of copper), and should have a nearly uniform composition. It is a rather coarse powder, or, more properly speaking, crystal, and settles rapidly in water, which is its greatest fault. It costs about 20 cents a pound.

Scheele's green is similar to Paris green in color, and differs from it only in lacking acetic acid; in other words, it is a simple arsenite of copper. It is a finer powder than Paris green, and therefore more easily kept in suspension, and has the additional advantage of costing only about half as much per pound. It is used in the same way and at about the same strength as Paris green and London purple.

London purple is a waste product in the manufacture of aniline dyes and contains a number of substances, chief of which are arsenic and lime. It is quite variable in the amount of arsenic and is not so effective as the green poisons and is much more apt to scald unless mixed with lime. It comes as a very fine powder, and is more easily kept in suspension than Paris green. It costs about 10 cents a pound.

Arsenite of lead is prepared by combining, approximately, 3 parts of the arsenite of soda with 7 parts of the acetate of lead (white sugar of lead) in water. These substances when pulverized unite readily and form a white precipitate, which is more easily kept suspended in water

¹ *Hellebore*.—The powdered roots of the white hellebore (*Veratrum viride*) are often recommended and used as an insecticide, particularly as a substitute for the arsenites. This substance is useful when a few plants only are to be sprayed, as in yards and small gardens, but is too expensive for large operations. It kills insects in the same way as the arsenicals, as an internal poison, and is less dangerous to man and the higher animals; but if sufficient be taken it will cause death. It is particularly effective against the larvæ of sawflies, such as the cherry slug, rose slug, currant worms, and strawberry worms.

It may be applied as a dry powder, preferably diluted with from 5 to 10 parts of flour, and dusted on the plants through a muslin bag or with powder bellows. The application should be made in the evening, when the plants are moist with dew. Used as a wet application, it should be mixed with water in the proportion of 1 ounce to the gallon of water and applied as a spray.

than any of the other poisons. Bought wholesale, the acetate of lead costs about $7\frac{1}{2}$ cents a pound, and the arsenite of soda 5 cents a pound. It may be used at any strength from 3 to 15 pounds to the 100 gallons of water without injury to the foliage, and in this respect is much safer on delicate plants than any other arsenical. Its use is advised where excessive strengths are desirable or with delicate plants where scalding is otherwise liable to result.

In point of solubility and corresponding danger of scalding the foliage these arsenicals fall in the following order, the least soluble first: Arsenite of lead, Paris green, Scheele's green, and London purple. The difference between the first three is not great in the particulars noted nor also in point of effectiveness against larvæ or other insects. London purple is ordinarily considerably less effective.

HOW TO APPLY ARSENICALS.

There are three principal methods of applying arsenicals. The wet method, which consists in using these poisons in water in the form of spray, is the standard means, secures uniform results at least expense, and is the only practical method of protecting fruit and shade trees. The dry application of these poisons in the form of a powder, which is dusted over plants, is more popular as a means against the cotton worm in the South, where the rapidity of treatment possible by this method, and its cheapness, give it a value against this insect, in the practical treatment of which prompt and economical action are the essentials. This method is also feasible for any low-growing crop, such as the potato, young cabbages, or other plants not to be immediately employed as food. The third method consists in the use of the arsenicals in the form of poisoned baits, and is particularly available for such insects as cutworms, wireworms, and locusts in local invasions.

The wet method.—Either Paris green, Scheele's green, or London purple may be used at the rate of 1 pound to 100 to 250 gallons of water, or 1 ounce to 6 to 15 gallons. The stronger mixtures are for such vigorous foliage as that of the potato for the Colorado potato-beetle, and the greater dilutions for the more tender foliage of the peach or plum. An average of 1 pound to 150 gallons of water is a good strength for general purposes. The poison should be first made into a thin paste in a small quantity of water and powdered or quick lime added in amount equal to the poison used to take up the free arsenic and remove or lessen the danger of scalding. An excess of lime will do no injury. The poisons thus mixed should be strained into the spray tank or reservoir, care being taken that all the poison is pulverized and washed through the meshes of the strainer. The use of the lime is especially desirable in the case of the peach and plum, the foliage of which, particularly the former, is very tender and easily scalded. To the stronger foliage of the apple and most shade trees Paris green may be applied without danger at the strength of 1 pound to 150 gallons of water; with London purple it is always better to use the lime.

The arsenite of lead is prepared by carefully pulverizing and combining, in a small quantity of water, the weight of the two ingredients needed at the strength decided upon as indicated by the capacity of the spray tank. The chemical combination is effected in a few minutes and the resulting milky mixture is ready for the tank. Lime is not needed with this arsenical. At slightly greater expense this arsenical can be procured already combined as a dry powder, white or colored with a dye.

If it be desirable to apply a fungicide at the same time, as on the apple for the codling moth and the apple scab fungus, the Bordeaux mixture¹ may be used instead of water, adding the arsenical to it at the same rate per gallon as when water is used. The lime in this fungicide neutralizes any excess of free arsenic and makes it an excellent medium for the arsenical, removing, as it does, all liability of scalding the foliage and enabling an application of the arsenical, if necessary, eight or ten times as strong as it could be employed with water alone.

The arsenicals can not be safely used with most other fungicides, such as the sulphate of copper, eau celeste or iron chloride solution, the scalding effects of these being greatly intensified in the mixture.

The dry method.—The following description applies to the pole-and-bag duster commonly used against the cotton worm: A pole 5 to 8 feet long and about 2 inches in diameter is taken, and a three fourths inch hole bored through it within 6 inches of each end. Near each end is securely tacked a bag of "8-ounce osnaburg cloth," 1 foot wide and 18 inches to 2 feet long, so that the powdered poison may be introduced into the bags with a funnel through the holes at the ends of the pole. The bags are filled with undiluted Paris green, which is generally preferred to London purple on account of its quicker action, and the apparatus is carried on horse or mule back, through the cotton fields, dusting two or four rows at once. The shaking induced by the motion of the animal going at a brisk walk or at a trot is sufficient to dust the

¹*Bordeaux mixture formula.*—Into a 50-gallon barrel pour 30 gallons of water, and suspend in it 6 pounds of bluestone in coarse sacking. Slack 4 pounds of fresh lime in another vessel, adding water slowly to obtain a creamy liquid, free from grit. When the bluestone is dissolved add the lime milk slowly with water enough to fill the barrel, stirring constantly.

With insufficient lime the mixture sometimes injures the foliage, and it should be tested with a solution obtained by dissolving an ounce of yellow prussiate of potash (potassium ferrocyanide) in one-half pint of water. If there be insufficient lime in the Bordeaux mixture the addition of a drop or two of this solution will cause a brownish-red color, and more lime should be added until no change takes place when the solution is dropped in. Use the Bordeaux mixture promptly, as it deteriorates on standing.

Stock solutions of both the bluestone and lime may be kept for any length of time. Make the stock bluestone by dissolving in water at the rate of 2 pounds to the gallon. The stock lime is slacked and kept as a thick paste. Cover both mixtures, to prevent evaporation and keep the lime moist. For the 50-gallon formula add 3 gallons of the bluestone solution to 50 gallons of water, and introduce the stock lime slowly until there is no reaction with the testing solution.—GALLOWAY.

plants thoroughly, or the pole may be jarred by hand. The application is preferably made in early morning or late evening, when the dew is on, to cause the poison to adhere better to the foliage.

From 1 to 2 pounds are required to the acre, and from 10 to 20 acres are covered in a day. The occurrence of heavy rains may necessitate a second application, but frequently one will suffice. This simple apparatus, on account of its effectiveness and cheapness, is employed throughout the cotton belt to the general exclusion of more complicated and expensive machinery.

With the patented air-blast machines for the dry distribution of poisons, arsenicals are diluted with 10 parts of flour, lime, or ground gypsum, and from 60 to 75 acres may be covered in a day by using relays of men and teams. Greater uniformity is secured with these machines in distribution of the poisons, but their cost (from \$30 to \$60) prevents their general use.

The planter should have a good supply of poison on hand and apparatus for its application prepared in advance, since when the worm puts in an appearance its progress is very rapid, and a delay of a single day may result in material damage to the crop.

If small garden patches are dusted with poison by this or similar means from bags or with hand bellows, it is advisable always to dilute the poison with 10 parts of flour, or preferably lime, and for application to vegetables which will ultimately be used for food, as the cabbage, 1 ounce of the poison should be mixed with 6 pounds of flour or 10 of lime and dusted merely enough to show evenly over the surface.

As poisoned bait.—It is not always advisable or effective to apply arsenicals directly to the plants, and this is particularly true in the case of the attacks of the grasshopper and of the various cutworms and wireworms. In such cases the use of poisoned bait has proved very satisfactory.

For locusts, take 1 part, by weight, of white arsenic, 1 of sugar, and 6 of bran, to which add water to make a wet mash. Place a tablespoonful of this at the base of each tree or vine, or apply a line of baits just ahead of the advancing army of grasshoppers, placing a tablespoonful of the mash every 6 or 8 feet, and following up with another line behind the first.

For baiting cutworms and wireworms, distribute poisoned green, succulent vegetation, such as freshly cut clover, in small bunches about in the infested fields. Dip the bait in a very strong arsenical solution, and protect from drying by covering with boards or stones. Renew the bait as often as it becomes dry, or every three to five days. The bran-arsenic bait will also answer for cutworms.

TIME TO SPRAY FOR BITING INSECTS.

For the codling moth, the apple and pear should receive the first application very soon after the blossoms fall, which is also the time for the second treatment of the scab fungus; the second spraying should be

given one or two weeks later, just before the fruit turns down on the stem or when it is from one-fourth to one-half inch in diameter. The first spraying reaches the eggs laid by the moth in the flower end of the fruit shortly after the falling of the blossoms, and the second, the later egg-laying by the more belated moths, when the first coating of poison will probably have been washed off by rains. The young larva, eating its way from without into the fruit, gets enough of the poison to destroy it. This treatment reaches at the same time a large number of leaf-feeding enemies of these fruit trees.

For the curculio of the stone fruits—plum, cherry, peach, etc.—two or three applications should be made; the first before the trees bloom, or as soon as the foliage is well started, the second at the time of the exposure of the young fruit by the falling of the blossoms, and perhaps a third a week later, particularly if rains have intervened after the last treatment. The poison here acts to destroy the parent curculio instead of the young larvæ, which, hatching from eggs placed beneath the skin of the fruit, are not affected by the poison on the outside. The adult curculio, however, as soon as it comes from its hibernation, feeds on the foliage before the trees bloom, and later on the young fruit also, and is destroyed by the arsenical before its eggs are deposited.

For leaf-feeding insects in general, such as the Colorado potato-beetle, blister beetles, elm leaf-beetle, maple worm, etc., the application should be made at the earliest indication of injury and repeated as often as necessary.

Fruit trees should never be sprayed when in bloom, on account of the liability of poisoning honeybees or other insects useful as cross fertilizers.

CARE IN USE OF ARSENICALS.

It must be remembered that these arsenicals are very poisonous and should be so labeled. If ordinary precautions are taken there is no danger to man or team attending their application. The wetting of any, which can not always be avoided, is not at all dangerous, on account of the great dilution of the mixture, and no ill effects whatever have resulted from this source. With some individuals the arsenite of lead, when in strong mixture, affects the eyes, but this is unusual and with a little care in spraying the mist need not strike the operator at all.

The poison disappears from the plants almost completely within twenty to twenty-five days, and even if the plants were consumed shortly after the application an impossible quantity would have to be eaten to get a poisonous dose. To illustrate, in the case of the apple, if the entire fruit were eaten, core and all, it would take several barrels at a single sitting to make a poisonous dose (Riley), and with the cabbage, dusted as recommended above, 28 heads would have to be eaten at one meal to reach this result (Gillette). It is preferable, however, to use other insecticides in the case of vegetables soon to be eaten, and thus avoid all appearance of danger.

INSECTICIDES FOR EXTERNAL SUCKING INSECTS (CONTACT POISONS).

The simple remedies for this class of insects, such as soap, insect powder, sulphur, tobacco decoction, etc., are frequently of value, but need little special explanation. Some brief notes will be given, however, describing the methods of using some of these substances which are easily available and will often be of service, particularly where few plants are to be treated. The standard remedies for this group of insects, viz, the kerosene emulsions, resin washes, lime, sulphur, and salt wash, hydrocyanic acid gas, and vapor of bisulphide of carbon will be afterwards treated in the order mentioned.

SOAPS AS INSECTICIDES.

Any good soap is effective in destroying soft-bodied insects, such as plant-lice and young or soft-bodied larvæ. The soaps made of fish oil and sold under the name of whale-oil soaps are often especially valuable, but variable in composition and merits. A soap made with caustic potash rather than with caustic soda, as is commonly the case, should be demanded, the potash soap yielding a liquid in dilution more readily sprayed and more effective against insects.

For plant-lice and delicate larvæ, such as the pear slug, a strength obtained by dissolving half a pound of soap in a gallon of water is sufficient. Soft soap will answer as well as hard, but at least double quantity should be taken.

As winter washes the fish-oil soaps have proved the most effective means of destroying certain scale insects, and have been particularly serviceable against the very resistant San Jose scale. For winter applications the soap is employed at the rate of 2 pounds to the gallon of water, and is applied hot with a spray pump as soon as the leaves fall in the autumn, repeating if necessary in the spring before the buds unfold.

PYRETHRUM, OR INSECT POWDER.

This insecticide is sold under the names of Bubach and Persian insect powder, or simply insect powder, and is the ground-up flowers of the Pyrethrum plant. It acts on insects externally through their breathing pores, and is fatal to many forms both of biting and sucking insects. It is not poisonous to man or the higher animals, and hence may be used where poisons would be objectionable. Its chief value is against household pests, such as roaches, flies, and ants, and in greenhouses, conservatories, and small gardens, where the use of arsenical poisons would be inadvisable.

It is used as a dry powder, pure or diluted with flour, in which form it may be puffed about rooms or over plants. On the latter it is preferably applied in the evening, so as to be retained by the dew. To keep out mosquitoes, and also to kill them, burning the powder in a tent or a room will give satisfactory results.

It may also be used as a spray at the rate of 1 ounce to 2 gallons of water, but in this case should be mixed some twenty-four hours before being applied. For immediate use, a decoction may be prepared by boiling in water from five to ten minutes.

SULPHUR.

Flowers of sulphur is one of the best remedies for plant mites such as the red spider, six-spotted orange mite, rust mite of the citrus fruits, etc. Applied at the rate of 1 ounce to a gallon of water, or mixed with some other insecticide, such as kerosene emulsion, it is a very effective remedy. For the rust mite, sprinkling the sulphur about under the trees is sometimes sufficient in moist climates to keep the fruit bright. Sulphur is often used to rid poultry houses of vermin, and when fed to cattle is said to be a good means of ridding them of lice, or it may be mixed with grease, oil, etc., and rubbed into the skin.

BISULPHIDE OF LIME.

This chemical is even better than sulphur as a remedy for mites. It is a liquid, and can be diluted easily to any extent. It can be made very cheaply by boiling together, in a small quantity of water, equal parts of lime and flowers of sulphur. For mites take 5 pounds of sulphur and 5 pounds of lime, and boil in a small quantity of water until both are dissolved and a brownish liquid results. Dilute to 100 gallons.

PURE KEROSENE.

Kerosene, or coal oil, is occasionally used directly against insects, although its importance as an insecticide is in the combinations with soap and milk described below. Under exceptional conditions it may be sprayed directly on living plants, and it has been so used, even in the growing season, without injury. It is apt, however, even in the dormant season, on leafless plants, to do serious injury or to kill the plant outright. The pure oil should only be applied as a winter wash to the older parts of plants, either in a spray or with a sponge, using the least possible quantity. Its use is not advised save in exceptionally bad cases of infestation and during the dormant period, and should never be attempted after the first sign of spring growth appears.

Kerosene is now being used to a certain extent, also, mechanically combined with water in the act of spraying, and is less harmful in this way than when used pure, as it is broken up more finely and is better distributed; but the danger to tender plants is not altogether avoided by this means.

Many insects which can not be destroyed by ordinary insecticides, or where it is unsafe to spray the plants themselves, may be killed by jarring them from the plants into pans of water on which a little kerosene is floating, or they may be shaken from the plants onto cloth screens saturated with kerosene, the crude product being preferable for the latter purpose.

As a remedy for the mosquito, kerosene has proved very effective. It is employed to destroy the larvæ of the mosquitoes in their favorite breeding places in small pools, still ponds, or stagnant water; and where such bodies of water are not sources of drinking supply or of value for their fish, especially in the case of temporary pools from rains, which frequently breed very disagreeable local swarms, the use of oil is strongly recommended. The kerosene is applied at the rate of 1 ounce to 15 square feet of water surface. It forms a uniform film over the surface and destroys all forms of aquatic insect life, including the larvæ of the mosquito, and also the adult females coming to the water to deposit their eggs. The application retains its efficiency for several weeks, even with the occurrence of heavy rains.

THE KEROSENE WASHES.

The kerosene and soap emulsion formula.

Kerosene.....	gallons..	2
Whale-oil soap (or 1 quart soft soap).....	pound..	$\frac{1}{2}$
Water.....	gallon..	1

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, the emulsion will keep indefinitely, and should be diluted only as wanted for use.

For the treatment of large orchards or in municipal work requiring large quantities of the emulsion, it will be advisable to manufacture it with the aid of a steam or gasoline engine, as has been very successfully and economically done in several instances, all the work of heating, churning, etc., being accomplished by this means.

The use of whale-oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, and does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft soap answers very well, and 1 quart of it may be taken in lieu of the hard soaps.

In limestone regions, or where the water is very hard, some of the soap will combine with the lime or magnesia in the water and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye, or rain water employed; but better than either, follow the milk emulsion formula, with which the character of the water, whether hard or soft, does not affect the result.

The kerosene and milk emulsion formula.

Kerosene	gallons..	2
Milk (sour)	gallon..	1

Heating is unnecessary in making the milk emulsion, which otherwise is churned as in the former case. The change from a watery liquid to a thick buttery consistency, much thicker than with the soap, takes place very suddenly after three to five minutes' agitation. With sweet milk difficulty will frequently be experienced, and if the emulsion does not result in five minutes, the addition of a little vinegar will induce prompt action. It is better to prepare the milk emulsion from time to time for immediate use, unless it can be stored in quantity in air-tight jars, otherwise it will ferment and spoil after a week or two.

How to use the emulsions.—During the growing period of summer, for most plant-lice and other soft-bodied insects, dilute the emulsion with from 15 to 20 parts of water; for the red spider and other plant mites the same, with the addition of 1 ounce of flowers of sulphur to the gallon; for scale insects, the larger plant-bugs, larvæ, and beetles, dilute with from 7 to 9 parts water; apply with spray pump.

For winter applications to the trunks and larger limbs of trees in the dormant and leafless condition, to destroy scale insects stronger mixtures may be used even to the pure emulsion, which latter can not be sprayed successfully, but may be applied with brush or sponge. Diluted with one or more parts of water it may be applied in spray without difficulty. The use of the pure emulsion is heroic treatment and only advisable in cases of excessive infestation, and in general it is much better and safer to defer the treatment until the young scales hatch in the spring, when the nine-times diluted wash may be used with more certain results and without danger to plants. The winter treatment should be followed by a use of the spring wash to destroy any young which may come from female scales escaping the stronger mixture.

Caution.—In the use of kerosene washes, and, in fact, of all oily washes on plants, the application should be just sufficient to wet the plant, without allowing the liquid to run down the trunk and collect about the crown. Usually at this situation there is a cavity formed by the swaying of the plants in the wind, and accumulation of the insecticide at this point, unless precautions be taken, may result in the death or injury of the plant. It is advisable to mound up the trees before spraying and firmly pack the earth about the bases whenever it is necessary to drench them thoroughly; and care should be taken in refilling the tank that no free oil is allowed to accumulate gradually in the residue left at the bottom.

THE RESIN WASH.

This wash has proved of greatest value in California, particularly against the red scale (*Aspidiotus aurantii*) and the black scale (*Lecanium*

olea) on citrus plants, and the last named and the San Jose scale (*Aspidiotus perniciosus*) on deciduous plants, and will be of use in all similar climates where the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and where, owing to the warmth, the multiplication of the scale insects continues almost without interruption throughout the year. Where rains are liable to occur at short intervals, and in the Northern States, the quicker-acting and stronger kerosene washes and heavy soap applications are preferable. The resin wash acts by contact, having a certain caustic effect, but principally by forming an impervious, smothering coating over the scale insects. The application may be more liberal than with the kerosene washes, the object being to wet the bark thoroughly.

The wash may be made as follows:

Resin.....	pounds..	20
Crude caustic soda (78 per cent).....	do.....	5
Fish oil.....	pints..	2½
Water to make.....	gallons..	100

Ordinary commercial resin is used, and the caustic soda is that put up for soap establishments, in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (98 per cent) used— $3\frac{1}{2}$ pounds of the latter being the equivalent of 5 pounds of the former. Place these substances, with the oil, in a kettle with water to cover them to a depth of 3 or 4 inches. Boil about two hours, making occasional additions of water, or until the compound resembles very strong, black coffee. Dilute to one-third the final bulk with hot water, or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed the mixture should be perfectly fluid, without sediment, and should any appear in the stock mixture reheating should be resorted to, and in fact the wash is preferably applied hot.

As a winter wash for scale insects, and particularly for the more resistant San Jose scale (*Aspidiotus perniciosus*), stronger washes are necessary. In southern California, for this latter insect, the equivalent of a dilution one-third less, or $66\frac{2}{3}$ gallons instead of 100, has given very good satisfaction. In Maryland, with this insect, it has proved necessary to use the wash at 6 times the summer strength to destroy all of the well-protected hibernating scales; and with other scale insects much stronger mixtures than those used in California have proved ineffectual in the East. For regions, therefore, with moderately severe winters, the use of the resin wash to destroy hibernating scale insects seems inadvisable.

THE LIME, SALT, AND SULPHUR WASH.

This is the almost invariable remedy for the San Jose scale in California, and over much of the State it is undoubtedly very effective. Experience with this wash in the East had thrown doubt on its real

efficiency as an insecticide, and it has been clearly demonstrated that under the climatic conditions east of the Alleghanies it is almost valueless. In California, however, the demonstration of its usefulness against the San Jose scale is complete, and the benefit of its application to orchards is most manifest. In the vicinity of Pomona, Cal., unsprayed orchards are as badly infested with San Jose scale as any of the invaded Eastern orchards are to-day, while in adjoining sprayed orchards the scale is entirely killed and the trees are rapidly recovering and showing vigorous and healthy new growth. In contiguous orchards, also of the same kinds of trees, similarly treated, so far as cultivation is concerned, the trees which have been subjected to yearly spraying are at least one-third larger than untreated trees. This wash is of value also as a fungicide, protecting stone fruits from leaf fungi, and is also a protection against birds, the common California linnet doing great damage to buds in January and February. The wash is almost invariably made and applied by contractors, and costs about 5 cents per gallon applied to the trees. It is a winter application, being applied in January and February.

Along the coast region and in northern California, where moister conditions prevail, this wash is very much less successful, bearing out somewhat the experience of the East, and doubtless explained by the similarity of climate in the districts mentioned with that of the Atlantic seaboard.

In making this wash the chief consideration seems to be prolonged boiling. The wash itself is practically a sulphide of lime, with free lime and salt carried with it. Prolonged boiling will result in taking up, temporarily at least, additional sulphur, and will perhaps add to its caustic properties. The proportions of the ingredients and the method of combining them varies slightly in different sections. The following is the ordinary formula: Unslaked lime, 40 pounds; sulphur, 20 pounds; salt, 15 pounds; one-fourth of the lime is first slaked and boiled with the sulphur in 20 gallons of water for two or three hours; the remainder of the lime is slaked and together with the salt is added to the hot mixture and the whole boiled for a half hour or an hour longer. Water is then added to make 60 gallons of wash. This wash is applied practically every year, or as often as the San Jose scale manifests itself in any numbers. In the coast region and in the northern part of California it is necessary to apply it with greater frequency than in the interior districts.

TIME TO SPRAY FOR SUCKING INSECTS.

For the larger plant-bugs and the aphides, or active plant-lice, and all other sucking insects which are present on the plants injuriously for comparatively brief periods, or at most during summer only, the treatment should be immediate, and if in the form of spray on the plants, at a strength which will not injure growing vegetation.

For scale insects and some others, as the pear *Psylla*, which hibernate on the plants, two or more strengths are advised with most of the liquid insecticides recommended, the weaker for summer applications and the more concentrated as winter washes. The summer washes for scale insects are most effective against the young, and treatment should begin with the first appearance of the larvæ of the spring or any of the later broods, and should be followed at intervals of seven days with two or three additional applications. The first brood, for the majority of species in temperate regions, will appear during the first three weeks in May. Examination from time to time with a hand lens will enable one to determine when the young of any brood appear.

The winter washes may be used whenever summer treatment can not be successfully carried out, and are particularly advantageous in the case of deciduous plants with dense foliage which renders a thorough wetting difficult in summer, or with scale insects which are so irregular in the time of disclosing their young that many summer treatments would be necessary to secure anywhere near complete extermination. In the winter also, with deciduous trees, very much less liquid is required, and the spraying may be much more expeditiously and thoroughly done. In the case of badly infested trees, a vigorous pruning is advisable as a preliminary to treatment.

As winter washes for temperate regions the kerosene mixtures and whale-oil soap solutions, particularly the latter, have so far given the best results. These stronger mixtures may be applied at any time during the dormant period of vegetation, and, with deciduous trees, preferably immediately after the falling of the foliage. In the growing season any of these stronger washes would cause the loss of foliage and fruit, and the more concentrated probably the death of the plant.

THE GAS TREATMENT.

Hydrocyanic acid gas.

The use of hydrocyanic acid gas originated in California, and was perfected by a long period of experimentation by an agent of this division, Mr. D. W. Coquillet. It has not been followed to any extent elsewhere, however; but in southern California it is held to be the best treatment for citrus trees and is now better understood and more satisfactory than ever before. It is especially applicable to citrus trees, the abundance of foliage and nature of the growth of which enables comparatively heavy tents to be thrown over them rapidly without danger of breaking the limbs. With deciduous trees it has not been practicable to use this gas to any extent, except in the case of nursery stock, which may be brought together compactly and treated in mass under tents. This gas is also the principal agency employed in disinfecting material coming into California from abroad. Recently it has been introduced into the East, more particularly in connection with nursery stock, to combat the San Jose scale.

Treatment consists in inclosing a tree (or nursery stock in greater or less quantities at once) with a tent and filling the latter with the poisonous fumes generated with potassium cyanide and sulphuric acid.

The present practice of "gassing" or "fumigating," as it is called, differs very little from the method employed a number of years ago when the process was first perfected, the main difference being in the fact that refined cyanide (98 per cent) is generally used in preference to the fused 58 per cent grade hitherto employed. The latter gives good results when it is uniform, but, unfortunately, this is rarely the case, and even in different parts of the same barrel great variation often occurs. Only about two-thirds as much of the stronger cyanide is used

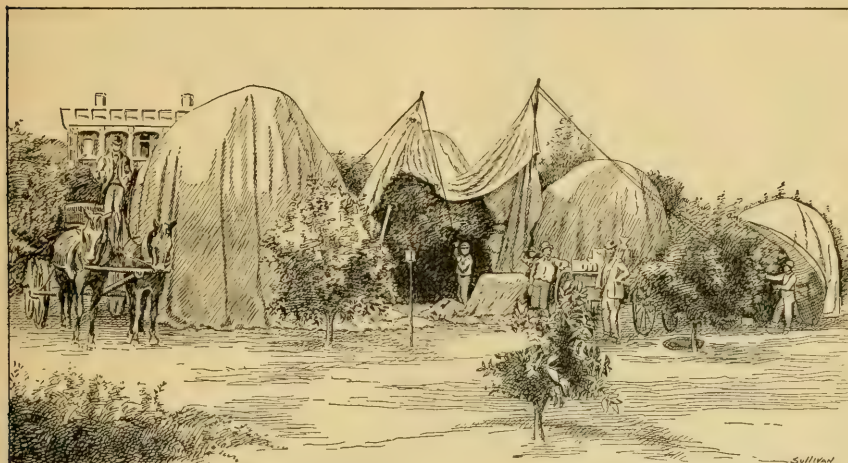


FIG. 1.—Tenting trees for gas treatment, San Diego, Cal. (author's illustration).

as of the weaker grade. The following table, prepared by Mr. John Scott, horticultural commissioner of Los Angeles County, gives the proportion with the stronger cyanide for trees of different sizes:

Height of tree (feet).	Diameter through foliage (feet).	Water (fluid ounces).	Sulphuric acid (fluid ounces).	Cyanide potassium (ounces).
6	4	1	$\frac{1}{2}$	$\frac{1}{2}$
8	6	$2\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{4}$
10	8	$3\frac{1}{2}$	2	2
12	10	6	3	3
12	14	9	$4\frac{1}{2}$	$4\frac{1}{2}$
14	14	10	5	5
16	16	12	$5\frac{1}{2}$	$5\frac{1}{2}$
18	16	12	6	6
20	16	13	$6\frac{1}{2}$	$6\frac{1}{2}$
22	18	15	$7\frac{1}{4}$	$7\frac{1}{4}$
24	20	16	8	8
26	20	$16\frac{1}{2}$	$8\frac{1}{2}$	$8\frac{1}{2}$
30	20	$17\frac{1}{2}$	$8\frac{1}{2}$	$8\frac{1}{2}$

The old statement that less time is required for small trees or plants than for larger ones is found to be an error, and, in fact, it is reasonable that an insect is no more easily killed on a small plant than on a large one. The limit in application of gas is to apply it at a strength and for a length of time, forty to forty-five minutes, as great as the tree can stand, and, in fact, the tender terminals of the tree should be slightly scalded, which is proof that the gas is of proper strength. Treatment of this character is necessary to destroy the more resistant scales. For very compact trees with dense foliage from one-fourth to one-third more gas should be generated, and this is true also of the moister coast regions, or within 10 miles of the coast in the West and for winter work on dormant plants in the East. In the case of young trees and nursery stock in foliage there is much less danger of scalding if the gas be generated slowly, either by employing a greater amount of water or using the cyanide in large lumps.

Trees are fumigated for the black scale in southern California in October, or preferably in November, the young black scales in this part of the State having usually all emerged by October 1. After the black scale has abandoned the leaves and gone back to the twigs and fixed itself firmly, the gas is not so effective against it. The red and other scales may be treated with gas at any time, but preferably at the season already alluded to. The applications are made at night, because the action of sunlight powerfully increases the scalding effect of the gas on the leaves. In California most of the work is done by contract, or under the direct supervision of the county horticultural commissioners, in some cases the tents and material being furnished at a mere nominal charge, together with one experienced man to superintend the work, while a crew of four men operate the tents, the wages of the director and men being paid by the owner of the trees.

The tents now employed are of two kinds, the "sheet" tent of octagonal shape for large trees, and the "ring" tent for trees under 12 feet in height. The ring tents, or, as they are also called, the bell tents, are bell-shaped and have a hoop of half-inch gas pipe fastened within a foot or so of the opening. Two men can easily throw one of these tents over a small tree. An equipment of 36 or 40 ring tents can be handled by four men. They are rapidly thrown over the trees by the crew, and the director follows closely and introduces the chemicals. By the time the last tent has been adjusted the first one can be removed and taken across to the adjoining row. An experienced crew, with one director, can treat 350 to 400 five-year-old trees, averaging in height 10 feet, in a single night of eleven or twelve hours. The cost under such conditions averages about 8 cents a tree.

With large trees the large sheet tents are drawn over them by means of uprights and pulley blocks. Two of these sheets are necessary for very large trees, the first being drawn halfway over and the second drawn up and made to overlap the first. In the case of trees from 24

to 30 years old and averaging 30 feet in height, about 50 can be treated in a night of ten or twelve hours, with an equipment of 12 or 15 tents, the cost being about 75 cents per tree. It is not practicable to treat trees above 30 feet in height.

The handling of the bell tents is simple and needs no further description, but the large tents are not so easily operated, and the method of adjusting the great flat octagonal sheets over the trees, while simple enough when once understood, will have, perhaps, some interest for Eastern fruit growers who may desire to experiment with the hydrocyanic acid gas. The only machinery employed consists of two simple up-rights, with attached blocks and tackle (fig. 2). The up-rights are about 25 feet high, of strong Oregon pine, 2 by 4 inches, and are provided at the bottom with a braced cross-bar to give them strength and to prevent their falling to either side while the tent is being raised. A guy rope is attached to the top of each pole and held to steady it by two of the crew stationed at the rear of the tree. The tent is hoisted by means of two ropes 70 feet long, which pass through blocks, one fixed at the top of the pole and the other free. The tent is caught near the edge by taking a hitch around some solid object, such as a green orange, about which the cloth is gathered. By this means the tent may be caught anywhere without the trouble of reversing and turning the heavy canvas to get at rings or other fastenings attached at particular points. The two remaining members of the operating crew draw the tent up against and over one side of the tree by means of the pulley ropes sufficiently to cover the other side of the tree when the tent falls. The poles and tent together are then allowed to fall forward, leaving the tent in position. Sufficient skill is soon acquired to carry out rapidly the details of this operation, so that



FIG. 2.—Method of hoisting sheet tent (after Craw).

little time is lost in transferring the tents from tree to tree, even when the trees approximate the limit in height. A single pair of hoisting poles answers for all the tents used.

Some practical experience is necessary to fumigate successfully, and it will therefore rarely be wise for anyone to undertake it on a large scale without having made preliminary experiments. If the cyanide treatment is to be introduced in the East, it would be well for fruit growers to obtain the services for a year or more of an experienced man from California to give them a practical illustration of methods, and even in California it is recognized that such work is much more economically accomplished when given over to experienced persons and done under contract. The gas treatment is probably the most thorough of all methods, but complete extermination is very rare. Fumigation must therefore be repeated every two or three years, or as often as the scale insects reappear in any numbers.

The canvas employed in the construction of tents may be rendered comparatively impervious to the gas by painting lightly with boiled linseed oil. This has the objection, however, of stiffening the fabric and adding considerably to its weight; it also frequently leads to its burning by spontaneous combustion unless carefully watched until the oil is dry. A much better material than oil is found in a product obtained from the leaves of the common prickly pear cactus (*Opuntia englemanni*), which grows in abundance in the Southwest. The liquor is obtained by soaking chopped-up leaves in water for twenty-four hours. It is given body and color by the addition of glue and yellow ochre or Venetian red, and is applied to both sides of the canvas and rubbed well into the fiber of the cloth with a brush.

Bisulphide of carbon vapor.

In line with the use of hydrocyanic acid gas is the employment of the vapor of bisulphide of carbon to destroy insects on low-growing plants, such as the lice on melon and squash vines. The treatment, as successfully practiced by Professors Garman and Smith, consists in covering the young vines with small tight boxes 12 to 18 inches in diameter, of either wood or paper, and introducing under each box a saucer containing one or two teaspoonfuls (1 or 2 drams) of the very volatile liquid, bisulphide of carbon. The vines of older plants may be wrapped about the hill and gathered in under larger boxes or tubs, and a greater, but proportional, amount of bisulphide used. The covering should be left over the plants for three-quarters of an hour to an hour, and with 50 to 100 boxes a field may be treated with comparative rapidity.

DUSTING AND SPRAYING APPARATUS.

For the application of powders the dusting bags already described are very satisfactory, or for garden work some of the small powder bellows and blowers are excellent. The best of these cost about \$2 each and are on the market in many styles.

Better apparatus is required for the wet applications where successful results require the breaking up of the liquid into a fine mist-like spray. The essential features of such an apparatus are a force pump, several yards of one-half inch cloth-reinforced hose with bamboo hoisting rod, and a spray tip. The size of the apparatus will depend on the amount of vegetation to be treated. For limited garden work and for the treatment of low plants the knapsack pumps or the small bucket force pumps are suitable, the former costing about \$14 and the latter from \$6 to \$9.

Ready fitted pumps, knapsack and others, for the application of insecticides, are now made by all the leading pump manufacturers of this country, and also large reservoirs with pump attached for extended orchard operations, the price of the latter ranging from \$25 to \$75.

The cost of a spraying outfit for orchard work may be greatly reduced by combining a suitable pump and fixtures with a home-constructed tank or barrel, to be mounted on a cart or wagon. A spray tank having a capacity of about 150 gallons is a very satisfactory size, and may be conveniently made 4 feet long by $2\frac{1}{2}$ wide by 2 deep, inside measurements. It should be carefully constructed, so as to be watertight, and should be strengthened by four iron bolts or rods across the ends, one each at the top and bottom. A good double-acting force pump may be obtained from any of the leading pump manufacturers at a cost of from \$10 to \$20, depending upon whether of iron or brass, and the nature of its fittings. For use in very large orchards or in city parks it may be advisable to construct the tank of twice the capacity mentioned, to expedite the spraying and to avoid the more frequent refillings necessary with the smaller tank.

For the requirements last mentioned the use of power spraying apparatus of considerable capacity has become somewhat general, particularly in municipal work against shade tree insects in the East, and in spraying the large citrus groves of the Pacific Slope. An apparatus of this sort recently built by the Division of Entomology of the Department is illustrated in the accompanying figure (fig. 3). The use of power apparatus for spraying is a special subject, and those interested would do well to consult the article by Dr. L. O. Howard (Yearbook Dept. Agric., 1896, pp. 69-88) giving full descriptive details, with figures, of the important machines now in use.

The more economical spray tips in the amount of liquid required are the different styles of cyclone nozzles, the best form of which is known to the market generally as the Vermorel nozzle. These are manufactured by the leading spray pump companies. Other good nozzles are also on the market. The common garden spraying and hose nozzles are much too coarse for satisfactory work, and are wasteful of the liquid.

A prime essential in spraying, especially where the large reservoirs are employed, is to keep the liquid constantly agitated to prevent the

settling of the poison to the bottom of the tank. This may be accomplished by constant stirring with a paddle, by shaking, but preferably by throwing a stream of the liquid back into the tank. Many of the larger pumps are now constructed with two discharge orifices with this latter object in view or are provided with special agitators, and the use of such is recommended.

For fruit trees of average size, or if apple, such as would produce from 10 to 15 bushels of fruit, from 3 to 7 gallons of spray are necessary to wet each tree thoroughly. For smaller trees, such as plum and cherry, 1 gallon to the tree will be sufficient. If an average of 5 gallons to the tree be taken for an apple orchard of 1,000 trees, 5,000

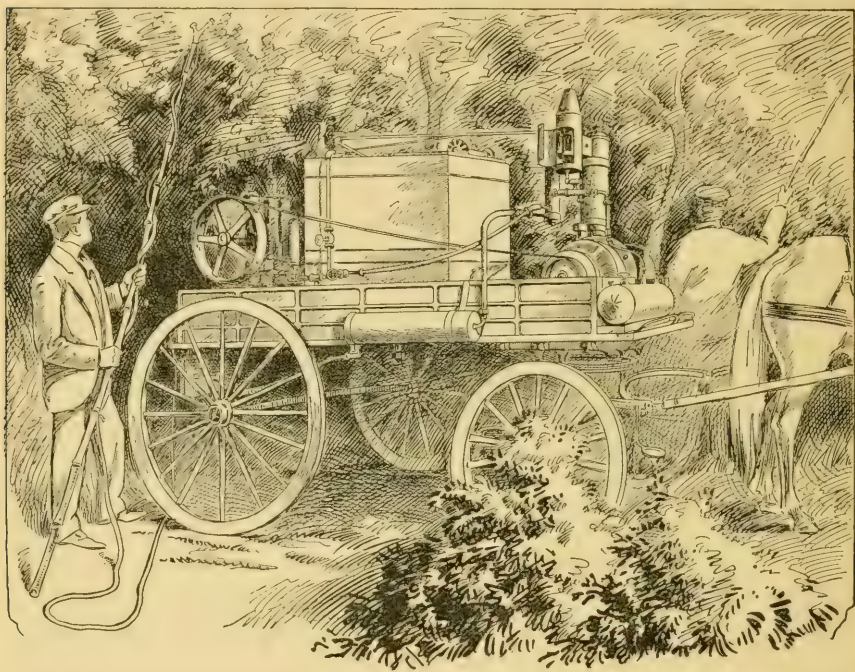


FIG. 3.—Gasoline power-spraying outfit of the Division of Entomology, U. S. Department of Agriculture (author's illustration).

gallons of spray would be required. About 33 pounds of Paris green or London purple would be needed for one spraying if used at the rate of 1 pound to 150 gallons of water, and for the two applications ordinarily recommended 66 pounds. This, for the Paris green, at 20 cents a pound, would amount to \$13.20, and the London purple, at 10 cents a pound, to \$6.60, or a little over 1 cent a tree for the former and one-half a cent for the latter.

In spraying orchard trees it will be found convenient in going between the rows to spray on each side, half of each tree in the row at a time and finish on the return, rather than attempt to spray all sides of one tree before taking up another.

The object in spraying is to coat every leaf and part of the plant as lightly as compatible with thoroughness, and to avoid waste in doing this a mist spray is essential. The application to any part should stop when water begins to drip from the leaves. A light rain will not remove the poison, but a dashing one will probably necessitate a renewal of the application.

REMEDIES FOR SUBTERRANEAN INSECTS.

Almost entire dependence is placed on the caustic washes, or those that act externally, for insects living beneath the soil on the roots of plants, including both sucking and biting insects, prominent among which are the white grubs, maggots in roots of cabbage, radishes, onions, etc., cutworms, wireworms, apple and peach root-lice, the grape phylloxera, and many others.

The insecticide must be one that will go into solution and be carried down by water. Of this sort are the kerosene emulsions and resin wash—the former preferable—the potash fertilizers, muriate and kainit, and bisulphide of carbon. The simple remedies are in applications of strong soap or tobacco washes to the soil about the crown; or soot, ashes, or tobacco dust buried about the roots; also similarly employed are lime and gas lime. Submersion, wherever the practice of irrigation or the natural conditions make it feasible, has also proved of the greatest service against the phylloxera.

HOT WATER.

As a means of destroying root-lice, and particularly the woolly louse of the apple, the most generally recommended measure hitherto is the use of hot water, and this, while being both simple and inexpensive, is thoroughly effective, as has been demonstrated by practical experience. Water at nearly the boiling point may be applied about the base of young trees without the slightest danger of injury to the trees, and should be used in sufficient quantity to wet the soil thoroughly to a depth of several inches, as the lice may penetrate nearly a foot below the surface. To facilitate the wetting of the roots and the extermination of the lice, as much of the surface soil as possible should be first removed.

By a hot-water bath slightly infested stock can easily be freed of the aphides at the time of its removal from the nursery rows. The soil should be dislodged and the roots pruned, and in batches of a dozen or so the roots and lower portion of the trunk should be immersed for a few seconds in water kept at a temperature of 130° to 150° F. A strong soap solution similarly heated or a fifteen times diluted kerosene emulsion will give somewhat greater penetration and be more effective, although the water alone at the temperature named should destroy the lice.

Badly infested nursery stock should be destroyed, since it would be worth little even with the aphides removed.

TOBACCO-DUST.

Some recent very successful experiments conducted by Mr. J. M. Stedman have demonstrated the very satisfactory protective as well as remedial value of finely ground tobacco dust against the woolly aphid. The desirability of excluding the aphid altogether from nursery stock is at once apparent, and this Mr. Stedman has shown to be possible by placing tobacco dust freely in the trenches in which the seedlings or grafts are planted and in the orchard excavations for young trees. Nursery stock may be continuously protected by laying each spring a line of the dust in a small furrow on either side of the row and as close as possible to the tree, covering loosely with earth. For large trees, both for protection and the destruction of existing aphides, from 2 to 5 pounds of the dust should be distributed from the crown outward to a distance of 2 feet, first removing the surface soil to a depth of from 4 to 6 inches. The tobacco kills the aphides by leaching through the soil, and acts as a bar for a year or so to reinfestation. The dust is a waste product of tobacco factories, costs about 1 cent per pound, and possesses the additional value of being worth fully its cost as a fertilizer.

KEROSENE EMULSION AND RESIN WASH.

Either the kerosene and soap emulsion or the resin wash, the former diluted 15 times and the latter at the strength of the winter mixture, are used to saturate the soil about the affected plants and either left to be carried down by the action of rains or washed down to greater depths by subsequent waterings.

For the grape phylloxera or the root-louse of the peach or apple, make excavations 2 or 3 feet in diameter and 6 inches deep about the base of the plant and pour in 5 gallons of the wash. If not a rainy season, a few hours later wash down with 5 gallons of water and repeat with a like amount the day following. It is better, however, to make this treatment in the spring, when the more frequent rains will take the place of the waterings.

For root-maggots enough of the wash is put along at the base of the plant to wet the soil to a depth of 1 to 2 inches, preferably followed after an hour with a like amount of water.

For white grubs in strawberry beds or in lawns the surface should be wetted with kerosene emulsion to a depth of 2 or 3 inches, following with copious waterings to be repeated for two or three days. The larvæ go to deeper and deeper levels and eventually die.

POTASH FERTILIZERS.

For white grubs, wireworms, cutworms, corn root-worms, and like insects, on the authority of Prof. J. B. Smith, either kainit or the muriate of potash, the former better, are broadcasted in fertilizing quantities, preferably before or during a rain, so that the material is

dissolved and carried into the soil at once. These not only act to destroy the larvæ in the soil, but are deterrents, and truck lands constantly fertilized by these substances are noticeably free from attacks of insects. This, in a measure, results from the increased vigor and greater resistant power of the plant, which of itself more than compensates for the cost of the treatment. The value of these fertilizers against the wireworms is, however, questioned by Prof. J. H. Comstock.

For the root-louse of peach and apple, work the fertilizer into the general surface of the soil about the trees, or put it in a trench about the tree 2 feet distant from the trunk.

For cabbage and onion maggots apply in little trenches along the roots at the rate of 300 to 500 pounds to the acre, and cover with soil.

These fertilizers (and the nitrate of soda is nearly as good) are also destructive to the various insects which enter the soil for hibernation or to undergo transformation.

BISULPHIDE OF CARBON.

This is the great French remedy for the phylloxera, 150,000 acres being now subjected to treatment with it, and applies equally well to all other root-inhabiting lice. The treatment is made at any season except the period of ripening of the fruit, and consists in making holes about the vines 1 foot to 16 inches deep and pouring into each about one-half ounce of bisulphide, and closing the hole with the foot. These injections are made about $1\frac{1}{2}$ feet apart, and not closer to the vines than 1 foot. It is better to make a large number of small doses than a few large ones. Hand injectors and injecting plows are employed in France to put the bisulphide into the soil about the vines, but a short stick or iron bar may be made to take the place of these injectors for limited tracts.

The use of bisulphide of carbon for the woolly aphis is the same as for the grape root-louse. It should be applied in two or three holes about the tree to a depth of 6 to 12 inches and not closer than $1\frac{1}{2}$ feet to the crown. An ounce of the chemical should be introduced into each hole, which should be immediately closed.

For root-maggots a teaspoonful is poured into a hole near the base of the plant, covering as above.

For ant nests an ounce of the substance is poured into each of several holes made in the space occupied by the ants, the openings being then closed; or the action is made more rapid by covering with a wet blanket for ten minutes and then exploding the vapor at the mouth of the holes with a torch, the explosion driving the fumes more thoroughly through the soil.

SUBMERSION.

This very successful means against the phylloxera is now practiced over some 75,000 acres of vineyards in France which were once destroyed by the grape root-louse, and the production and quality of fruit has been fully restored. In this country it will be particularly available

in California and in all arid districts where irrigation is practiced; otherwise it will be too expensive to be profitable. The best results are secured in soils in which the water will penetrate rather slowly, or from 6 to 18 inches in twenty-four hours; in loose, sandy soils it is impracticable on account of the great amount of water required. Submersion consists in keeping the soil of the vineyard flooded for from eight to twenty days after the fruit has been gathered and active growth of the vine ceased, or during September or October, but while the phylloxera is still in active development. Early in September eight to ten days will suffice; in October, fifteen to twenty days, and during the winter, as was formerly practiced, forty to sixty days. Supplementing the short fall submergence a liberal July irrigation, amounting to a forty-eight-hour flooding, is customary to reach any individuals surviving the fall treatment, and which in midsummer are very susceptible to the action of water.

To facilitate the operation, vineyards are commonly divided by embankments of earth into square or rectangular plots, the former for level and the latter for sloping ground, the retaining walls being protected by coverings of reed grass, etc., during the first year, or until they may be seeded to some forage plant.

This treatment will destroy many other root-attacking insects and those hibernating beneath the soil, and, in fact, is a very ancient practice in certain oriental countries bordering the Black Sea and the Grecian Archipelago.

REMEDIES FOR INSECTS AFFECTING GRAIN AND OTHER STORED PRODUCTS.

GENERAL METHODS OF TREATMENT.

The chief loss in this direction from insects is to grains in farmers' bins, or grain or grain products in stores, mills, and elevators, although in the warmer latitudes much of the injury results from infestation in the field between the ripening of the grain and its storage in bins or granaries. Fortunately, the several important grain insects are amenable to like treatment. Aside from various important preventive considerations, such as, in the South, prompt threshing of grain after harvesting, the thorough cleansing of bins before refilling, constant sweeping, removal of waste harboring insects from all parts of granaries and mills, and care to prevent the introduction of "weeviled" grain, there are three valuable remedial measures, viz, agitation of the grain, heating, and dosing with bisulphide of carbon.

The value of agitating or handling grain is well known, and whenever, as in elevators, grain can be transferred or poured from one bin into another grain pests are not likely to trouble. The benefit will depend upon the frequency and thoroughness of the agitation, and in France machines for shaking the grain violently have been used with

success. Winnowing weeviled grain is also an excellent preliminary treatment.

Raising the temperature of the grain in closed retorts or revolving cylinders to 130° to 150° F. will kill the inclosed insects if continued for from three to five hours, but is apt to injure the germ, and is not advised in case of seed stock. The simplest, cheapest, and most effectual remedy is the use of bisulphide of carbon.

BISULPHIDE OF CARBON.

This is a colorless liquid with very offensive odor, which, however, passes off completely in a short time. It readily volatilizes and the vapor, which is very deadly to insect life, is heavier than air and settles and fills any compartment or bin in the top of which the liquid is placed. It may be distributed in shallow dishes or tins or in saturated waste on the top of grain in bins, and the gas will settle and permeate throughout the mass of the grain. In large bins, to hasten and equalize the operation, it is well to put a quantity of the bisulphide in the center of the grain by thrusting in balls of cotton or waste tied to a stick and saturated with the liquid, or by means of a gas pipe loosely plugged at one end, down which the liquid may be poured and the plug then loosened with a rod. Prof. H. E. Weed reports that in Mississippi the chemical is commonly poured directly onto the grain. In moderately tight bins no further precaution than to close them well need be taken, but in open bins it will be necessary to cover them over with a blanket to prevent the too rapid dissipation of the vapor. The bins or buildings should be kept closed from twenty-four to thirty-six hours, after which a thorough airing should be given them.

Limited quantities at a time may often be advantageously subjected to treatment in small bins before being placed for long storage in large masses, and especially whenever there is danger of introducing infested grain.

The bisulphide is applied at the rate of 1 pound to the ton of grain, or a pound to a cubic space 10 feet on a side.

In the case of mills, elevators, or larger granaries the application may be best made on Saturday night, leaving the building closed over Sunday, with a watchman without to see that no one enters, and to guard against fire. The bisulphide should be first distributed in the lower story, working upward to avoid the settling vapor, using the substance very freely, in waste or dishes, at all points of infestation and over bins throughout the building.

This insecticide may also be used in other stored products, as pease, beans, etc., and very satisfactorily where the infested material can be inclosed in a tight can, chest, or closet for treatment.

The bisulphide costs, in 50-pound cans, 10 cents per pound, and in small quantities, of druggists, 25 to 35 cents per pound.

Caution.—The bisulphide may be more freely employed with milling

grain than that intended for seedling, since when used excessively it may injure the germ. It must always be remembered that the vapor is highly inflammable and explosive, and that no fire or lighted cigars, etc., should be in the building during its use. If obtained in large quantities it should be kept in tightly closed vessels and away from fire, preferably in a small outbuilding.

GENERAL CONSIDERATIONS ON THE CONTROL OF INSECTS.

ADVANTAGE OF PROMPT TREATMENT.

The importance of promptness in the treatment of plants attacked by insects can not be too strongly insisted upon. The remedy often becomes useless if long deferred, the injury having already been accomplished or gone beyond repair. If, by careful inspection of plants from time to time, the injury can be detected at the very outset, treatment is comparatively easy and the result much more satisfactory. Preventive work, therefore, should be done as much as possible, rather than waiting for the remedial treatment later; the effort being to forestall any serious injury rather than to patch up damage which neglect has allowed to become considerable.

KILLING INSECTS AS A PROFESSION.

It may often happen that the amount of work in a community is sufficient to induce one or more persons to undertake the treatment of plants at a given charge per tree or per gallon of the insecticide employed. Where this is the case, and the contracting parties are evidently experienced and capable, it is frequently more economical in the end to employ such experienced persons, especially when a guarantee is given, rather than attempt to do the work one's self with the attending difficulty of preparing insecticides and securing apparatus for work on a comparatively small scale. In California this is a common practice, and also in some of our Eastern cities, and has worked excellently.

THE DETERMINATION OF THE RESULT OF TREATMENT.

It is often of importance to know when and how to determine the effect of any treatment applied directly to insects exposed on the surface of plants. In the case of scale insects, especially during the dormant condition in winter, the response to insecticides is very slow and gradual. The scale larvæ, or any young scales during the growing season, are killed in a few minutes, or a few hours at the furthest, just as any other soft-bodied insect, but the mature scale does not usually exhibit the effects of the wash for some time. Little can be judged, ordinarily, of the ultimate results before two weeks, and it is often necessary to wait two months to get final conclusions. The slow, progressive death of the scales is apparently due to the gradual penetra-

tion of the insecticide, and also to the softening and loosening of the scale itself, enabling subsequent weather conditions of moisture and cold to be more fatal.

With such biting insects as caterpillars and slug worms after treatment with arsenicals or other poisons death rapidly follows, the time being somewhat in proportion to the size of the larvæ and their natural vigor. Soft-bodied larvæ, such as the slug worms and very young larvæ of moths and beetles or other insects, are killed in a day or two. Large and strong larvæ sometimes survive the effect of poison for eight or ten days, and leaf-feeding beetles will often fly away and perish from the poison in their places of concealment.

Many larvæ or other forms of leaf-feeding insects, after taking one or two meals of poisoned foliage, will remain in a semitorpid and diseased condition on the plants for several days before they finally succumb. The protection to the plant, however, is just as great as though they had died immediately, but misapprehension may often arise and the poison may be deemed to have been of no service.

The complete extermination of insects on plants is often a very difficult, if not an impossible, undertaking. This is especially true of scale insects. In California even, where the work against these enemies of fruits has been most thorough and successful, experience has shown that the best that can be done is a practical elimination of the scale for the time being, and it is often necessary to repeat the treatment every year or two. In exceptional cases once in three years suffices. With leaf-feeding insects it is often possible to effect complete extermination with the use of arsenical poisons. Such sucking insects as plant-lice may also be completely exterminated. But in general all applications or methods of treatment must be recognized, more or less, as a continuous charge on the crop, as much so as are the ordinary cultural operations.

CONTROL OF INSECTS BY CULTURAL METHODS.

It is much easier to ward off an attack of insects or to make conditions unfavorable for their multiplication than to destroy them after they are once in possession; and in controlling them, methods and systems of farm and orchard culture have long been recognized as of the greatest value, more so even than the employment of insecticides, which, in most cases, can only stop an injury already begun. Insects thrive on neglect, multiply best in land seldom or never cultivated, and winter over in rubbish, prunings, or the undisturbed soil about their food plants, and become, under these conditions, more numerous every year. It is a fact of common observation that it is the neglected farm, vineyard, or orchard filled with weeds or wild growth which is certain to be stocked with all the principal insect enemies; and, on the other hand, thorough and constant culture, with the removal and burning of prunings, stubble, and other waste, the collection and destruction of fallen and diseased fruit, and the practice, where possible,

of fall plowing to disturb the hibernating quarters of field insects, will almost certainly be accompanied by comparative immunity from insect pests.

The vigor and healthfulness of plant growth has also much to do with freedom from insect injury, such plants seeming to have a native power of resistance which renders them, in a measure, distasteful to most insects, or at least able to throw off or withstand their attacks. A plant already weakened, however, or of lessened vitality from any cause, seems to be especially sought after, is almost sure to be the first affected, and furnishes a starting point for general infestation. Anything, therefore, which aids good culture in keeping plants strong and vigorous, such as the judicious use of fertilizers, will materially assist in preventing injury.

To the constant cropping of large areas of land year after year to the same staple is largely due the excessive loss from insects in this country as compared with European countries, because this practice furnishes the best possible conditions for the multiplication of the enemies of such crops. A most valuable cultural means, therefore, is a system of rotation of crops which will prevent the gradual yearly increase of the enemies of any particular staple by the substitution every year or two of other cultures not subject to the attacks of the insect enemies of the first.

With such insects as the Hessian fly, the squash borers, and many others which have regular times of appearance, much can be done, also, by the planting of early or late varieties, or by deferring seeding so as to avoid the periods of excessive danger. Wherever possible, varieties should be selected which experience has shown to be resistant to insect attack. Familiar illustrations of such resistant varieties in all classes of cultivated plants will occur to every practical man, and a better instance of the benefit to be derived from taking advantage of this knowledge can not be given than the almost universal adoption of resistant American vines as stocks for the regeneration of the vineyards of France destroyed by the phylloxera and for the similarly affected vineyards of European grapes in California.

In the case of stored grain pests, particularly the Angoumois moth, or so-called fly weevil, the chief danger in the South is while the grain is standing in shock or stack, after harvesting, during which period the insects have easy access to it. This source of infestation may be avoided by promptly threshing grain after harvesting and storing it in bulk. This will prevent the injury of more than the surface layer, as the insects are not likely to penetrate deeply into the mass of the grain.

These general notes are by no means new, but their importance justifies their repetition, as indicating the best preventive measures in connection with the remedial ones already given.

The overwhelming experience of the past dozen years makes it almost unnecessary to urge, on the ground of pecuniary returns, the adoption of the measures recommended in the foregoing pages against insects. To emphasize the value of such practice, it is only necessary to call attention to the fact that the loss to orchard, garden, and farm crops frequently amounts to from 15 to 75 per cent of the entire product, and innumerable instances could be pointed out where such loss has been sustained year after year, while now, by the adoption of remedial measures, large yields are regularly secured with an insignificant expenditure for treatment. It has been established that in the case of the apple crop spraying will protect from 50 to 75 per cent of the fruit which would otherwise be wormy, and that in actual marketing experience the price has been enhanced from \$1 to \$2.50 per barrel, and this at a cost of only about 10 cents per tree for labor and material.

In the case of one orchard in Virginia, only one-third of which was sprayed, the result was an increase in the yield of sound fruit in the portion treated of nearly 50 per cent, and an increase of the value of this fruit over the rest of 100 per cent. The loss from not having treated the other two-thirds was estimated at \$2,500. The saving to the plum crop and other small fruits frequently amounts to the securing of a perfect crop where otherwise no yield whatever of sound fruit could be secured.

An illustration, in the case of field insects, may also be given where, by the adoption of a system of rotation, in which oats were made to alternate with corn, the owner of a large farm in Indiana made a saving of \$10,000 per year, this amount representing the loss previously sustained annually from the corn root-worm. The cotton crop, which formerly in years of bad infestation by the leaf-worm was estimated to be injured to the extent of \$30,000,000, is now comparatively free from such injury, owing to the general use of arsenicals.

Facts of like import could be adduced in regard to many other leading staples, but the foregoing are sufficient to emphasize the money value of intelligent action against insect enemies, which, with the present competition and diminishing prices, may represent the difference between a profit and a loss in agricultural operations.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C.

[Only the bulletins named below are available for distribution.]

- No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. Pp. 8.
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- No. 18. Forage Plants for the South. Pp. 30.
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- No. 45. Some Insects Injurious to Stored Grain. Pp. 32.
- No. 46. Irrigation in Humid Climates. Pp. 26.
- No. 47. Insects Affecting the Cotton Plant. Pp. 32.
- No. 48. The Manuring of Cotton. Pp. 16.
- No. 49. Sheep Feeding. Pp. 24.
- No. 50. Sorghum as a Forage Crop. Pp. 24.
- No. 51. Standard Varieties of Chickens. Pp. 48.
- No. 52. The Sugar Beet. Pp. 48.
- No. 53. How to Grow Mushrooms. Pp. 20.
- No. 54. Some Common Birds in Their Relation to Agriculture. Pp. 40.
- No. 55. The Dairy Herd: Its Formation and Management. Pp. 24.
- No. 56. Experiment Station Work—I. Pp. 32.
- No. 57. Butter Making on the Farm. Pp. 16.

DIV. INSECT

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 19.

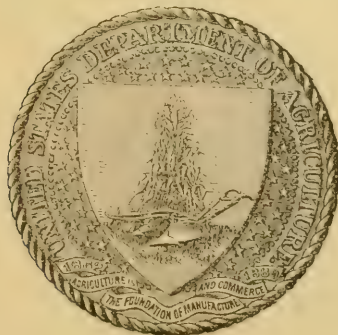
IMPORTANT INSECTICIDES:

DIRECTIONS FOR THEIR PREPARATION AND USE.

[FOURTH REVISED EDITION.]

BY

C. L. MARLATT, M. S.,
FIRST ASSISTANT ENTOMOLOGIST.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., July 15, 1898.

SIR: I have the honor to transmit herewith copy for a new edition of Farmers' Bulletin No. 19, revised to date. The bulletin was originally prepared under my direction by Mr. C. L. Marlatt, first assistant entomologist. Since the publication of the last edition some advance has been made in the subject of insecticides which necessitates the publication of some additional matter and some change in the methods of preparation of old and standard mixtures. The constant call for information of this character will warrant the publication of a fourth revised edition of this bulletin.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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IMPORTANT INSECTICIDES: DIRECTIONS FOR THEIR PREPARATION AND USE.

Without going minutely into the field of remedies and preventives for insect depredators, it is proposed to give in this bulletin brief directions concerning a few of the insecticide agents having the widest range and attended with the greatest usefulness, economy, and ease of application. These are not covered by patent, and in general it is true that the patented articles are inferior, and many of the better of them are in fact merely more or less close imitations of the standard substances and compounds hereinafter described. Only such brief references to food and other habits of the insects covered will be included as are necessary to illustrate the principles underlying the use of the several insecticide agents recommended.

RELATION OF FOOD HABITS TO REMEDIES.

For the intelligent and practical employment of insecticides it is necessary to comprehend the nature and method of injury commonly due to insects. Omitting for the present purpose the many special cases of injury which necessitate peculiar methods of treatment, the great mass of the harm to growing plants from the attacks of insects falls under two principal heads based on distinct principles of food economy of insects, viz, whether they are biting (mandibulate) or sucking (haustellate), each group involving a special system of treatment.

INJURY FROM BITING INSECTS.

The biting or gnawing insects are those which actually masticate and swallow some portion of the solid substance of the plant, as the wood, bark, leaves, flowers, or fruit. They include the majority of the injurious larvæ, many beetles, and the locusts.

For these insects direct poisons, such as the arsenicals, which may be safely applied to the leaves or other parts of the plant attacked, and which will be swallowed by the insect with its food, furnish the surest and simplest remedy, and should always be employed, except where the parts treated are themselves to be shortly used for the food of other animals or of man.

INJURY FROM SUCKING INSECTS.

The sucking insects are those which injure plants by the gradual extraction of the juices, either from the bark, leaves, or fruit, and include the plant-bugs, plant-lice, scale insects, thrips, and plant-feeding mites. These insects possess, instead of biting jaws, sucking beaks or bristles, which are thrust down through the outer layers of the bark or leaves into the soft, succulent tissues beneath and used to extract the plant juices, with a resulting injury not so noticeable as in the first group, but not less serious.

For this class of insects the application of poisons, which penetrate little, if at all, into the plant cells, is of trifling value, and it is necessary to use substances which will act externally on the bodies of these insects, either as a caustic or to smother or stifle them by closing their breathing pores, or to fill the air about them with poisonous fumes. Of value also as repellants are various deterrent or obnoxious substances.

Wherever it is not desirable to use poisons for biting insects, some of the means just enumerated will often be available.

GROUPS SUBJECT TO SPECIAL TREATMENT.

The general grouping outlined above relates to the species which live and feed upon the exterior of plants for some portion or all of their lives, and includes the great majority of the injurious species. Certain insects, however, owing to peculiarities of habit, inaccessibility, or other causes, require special methods of treatment. Of these, two groups properly come within the scope of this bulletin: (1) Those working beneath the soil, or subterranean insects, such as the white grubs, root-maggots, root-lice, etc., and (2) insects affecting stored products, as various grain and flour pests.

Three other groups, which include species requiring very diverse methods of treatment, and therefore not coming within the limits of this bulletin, are (1) the internal feeders, such as wood, bark, and stem borers, leaf-miners, gall insects, and species living within fruits; (2) household pests, and (3) animal parasites.

The classification of insects outlined above, based on mode of nourishment and indicating groups amenable to similar remedial treatment, simply stated, is as follows:

- I. External feeders:
 - (a) Biting insects.
 - (b) Sucking insects.
- II. Internal feeders.
- III. Subterranean insects.
- IV. Insects affecting stored products.
- V. Household pests.
- VI. Animal parasites.

INSECTICIDES FOR EXTERNAL BITING INSECTS (FOOD POISONS).

THE ARSENICALS: PARIS GREEN, SCHEELE'S GREEN, ARSENITE OF LEAD, AND LONDON PURPLE.

The arsenical compounds have supplanted, practically, all other substances for the insects falling under this heading.¹ The two arsenicals in most common use, and obtainable everywhere, are Paris green and London purple. The other two arsenicals mentioned, viz, Scheele's green and arsenite of lead, are less known and not so easily obtainable, but in some respects are better than the first-mentioned poisons, as will be shown later. The use of powdered white arsenic is not recommended on account of its great liability to scald foliage as well as for the fact that it is apt to be mistaken for harmless substances. The arsenicals mentioned have the following characteristics:

Paris green is a definite chemical compound of arsenic, copper, and acetic acid (known as the aceto-arsenite of copper), and should have a nearly uniform composition. It is a rather coarse powder, or, more properly speaking, crystal, and settles rapidly in water, which is its greatest fault. It costs about 20 cents a pound.

Scheele's green is similar to Paris green in color, and differs from it only in lacking acetic acid; in other words, it is a simple arsenite of copper. It is a finer powder than Paris green, and therefore more easily kept in suspension, and has the additional advantage of costing only about half as much per pound. It is used in the same way and at about the same strength as Paris green and London purple.

London purple is a waste product in the manufacture of aniline dyes and contains a number of substances, chief of which are arsenic and lime. It is quite variable in the amount of arsenic and is not so effective as the green poisons and is much more apt to scald unless mixed with lime. It comes as a very fine powder, and is more easily kept in suspension than Paris green. It costs about 10 cents a pound.

Arsenite of lead is prepared by combining, approximately, 3 parts of the arsenite of soda with 7 parts of the acetate of lead (white sugar of lead) in water. These substances when pulverized unite readily and form a white precipitate, which is more easily kept suspended in water

¹ *Hellebore*.—The powdered roots of the white hellebore (*Veratrum viride*) are often recommended and used as an insecticide, particularly as a substitute for the arsenites. This substance is useful when a few plants only are to be sprayed, as in yards and small gardens, but is too expensive for large operations. It kills insects in the same way as the arsenicals, as an internal poison, and is less dangerous to man and the higher animals; but if sufficient be taken it will cause death. It is particularly effective against the larvæ of sawflies, such as the cherry slug, rose slug, currant worms, and strawberry worms.

It may be applied as a dry powder, preferably diluted with from 5 to 10 parts of flour, and dusted on the plants through a muslin bag or with powder bellows. The application should be made in the evening, when the plants are moist with dew. Used as a wet application, it should be mixed with water in the proportion of 1 ounce to the gallon of water and applied as a spray.

than any of the other poisons. Bought wholesale, the acetate of lead costs about $7\frac{1}{2}$ cents a pound, and the arsenite of soda 5 cents a pound. It may be used at any strength from 3 to 15 pounds to the 100 gallons of water without injury to the foliage, and in this respect is much safer on delicate plants than any other arsenical. Its use is advised where excessive strengths are desirable or with delicate plants where scalding is otherwise liable to result.

In point of solubility and corresponding danger of scalding the foliage these arsenicals fall in the following order, the least soluble first: Arsenite of lead, Paris green, Scheele's green, and London purple. The difference between the first three is not great in the particulars noted nor also in point of effectiveness against larvæ or other insects. London purple is ordinarily considerably less effective.

HOW TO APPLY ARSENICALS.

There are three principal methods of applying arsenicals. The wet method, which consists in using these poisons in water in the form of spray, is the standard means, secures uniform results at least expense, and is the only practical method of protecting fruit and shade trees. The dry application of these poisons in the form of a powder, which is dusted over plants, is more popular as a means against the cotton worm in the South, where the rapidity of treatment possible by this method, and its cheapness, give it a value against this insect, in the practical treatment of which prompt and economical action are the essentials. This method is also feasible for any low-growing crop, such as the potato, young cabbages, or other plants not to be immediately employed as food. The third method consists in the use of the arsenicals in the form of poisoned baits, and is particularly available for such insects as cutworms, wireworms, and locusts in local invasions.

The wet method.—Either Paris green, Scheele's green, or London purple may be used at the rate of 1 pound to 100 to 250 gallons of water, or 1 ounce to 6 to 15 gallons. The stronger mixtures are for such vigorous foliage as that of the potato for the Colorado potato-beetle, and the greater dilutions for the more tender foliage of the peach or plum. An average of 1 pound to 150 gallons of water is a good strength for general purposes. The poison should be first made into a thin paste in a small quantity of water and powdered or quick lime added in amount equal to the poison used to take up the free arsenic and remove or lessen the danger of scalding. An excess of lime will do no injury. The poisons thus mixed should be strained into the spray tank or reservoir, care being taken that all the poison is pulverized and washed through the meshes of the strainer. The use of the lime is especially desirable in the case of the peach and plum, the foliage of which, particularly the former, is very tender and easily scalded. To the stronger foliage of the apple and most shade trees Paris green may be applied without danger at the strength of 1 pound to 150 gallons of water; with London purple it is always better to use the lime.

The arsenite of lead is prepared by carefully pulverizing and combining, in a small quantity of water, the weight of the two ingredients needed at the strength decided upon as indicated by the capacity of the spray tank. The chemical combination is effected in a few minutes and the resulting milky mixture is ready for the tank. Lime is not needed with this arsenical. At slightly greater expense this arsenical can be procured already combined as a dry powder, white or colored with a dye.

If it be desirable to apply a fungicide at the same time, as on the apple for the codling moth and the apple scab fungus, the Bordeaux mixture¹ may be used instead of water, adding the arsenical to it at the same rate per gallon as when water is used. The lime in this fungicide neutralizes any excess of free arsenic and makes it an excellent medium for the arsenical, removing, as it does, all liability of scalding the foliage and enabling an application of the arsenical, if necessary, eight or ten times as strong as it could be employed with water alone.

The arsenicals can not be safely used with most other fungicides, such as the sulphate of copper, eau celeste or iron chloride solution, the scalding effects of these being greatly intensified in the mixture.

The dry method.—The following description applies to the pole-and-bag duster commonly used against the cotton worm: A pole 5 to 8 feet long and about 2 inches in diameter is taken, and a three fourths inch hole bored through it within 6 inches of each end. Near each end is securely tacked a bag of "8-ounce osnaburg cloth," 1 foot wide and 18 inches to 2 feet long, so that the powdered poison may be introduced into the bags with a funnel through the holes at the ends of the pole. The bags are filled with undiluted Paris green, which is generally preferred to London purple on account of its quicker action, and the apparatus is carried on horse or mule back, through the cotton fields, dusting two or four rows at once. The shaking induced by the motion of the animal going at a brisk walk or at a trot is sufficient to dust the

¹*Bordeaux mixture formula.*—Into a 50-gallon barrel pour 30 gallons of water, and suspend in it 6 pounds of bluestone in coarse sacking. Slack 4 pounds of fresh lime in another vessel, adding water slowly to obtain a creamy liquid, free from grit. When the bluestone is dissolved add the lime milk slowly with water enough to fill the barrel, stirring constantly.

With insufficient lime the mixture sometimes injures the foliage, and it should be tested with a solution obtained by dissolving an ounce of yellow prussiate of potash (potassium ferrocyanide) in one-half pint of water. If there be insufficient lime in the Bordeaux mixture the addition of a drop or two of this solution will cause a brownish-red color, and more lime should be added until no change takes place when the solution is dropped in. Use the Bordeaux mixture promptly, as it deteriorates on standing.

Stock solutions of both the bluestone and lime may be kept for any length of time. Make the stock bluestone by dissolving in water at the rate of 2 pounds to the gallon. The stock lime is slacked and kept as a thick paste. Cover both mixtures, to prevent evaporation and keep the lime moist. For the 50-gallon formula add 3 gallons of the bluestone solution to 50 gallons of water, and introduce the stock lime slowly until there is no reaction with the testing solution.—GALLOWAY.

plants thoroughly, or the pole may be jarred by hand. The application is preferably made in early morning or late evening, when the dew is on, to cause the poison to adhere better to the foliage.

From 1 to 2 pounds are required to the acre, and from 10 to 20 acres are covered in a day. The occurrence of heavy rains may necessitate a second application, but frequently one will suffice. This simple apparatus, on account of its effectiveness and cheapness, is employed throughout the cotton belt to the general exclusion of more complicated and expensive machinery.

With the patented air-blast machines for the dry distribution of poisons, arsenicals are diluted with 10 parts of flour, lime, or ground gypsum, and from 60 to 75 acres may be covered in a day by using relays of men and teams. Greater uniformity is secured with these machines in distribution of the poisons, but their cost (from \$30 to \$60) prevents their general use.

The planter should have a good supply of poison on hand and apparatus for its application prepared in advance, since when the worm puts in an appearance its progress is very rapid, and a delay of a single day may result in material damage to the crop.

If small garden patches are dusted with poison by this or similar means from bags or with hand bellows, it is advisable always to dilute the poison with 10 parts of flour, or preferably lime, and for application to vegetables which will ultimately be used for food, as the cabbage, 1 ounce of the poison should be mixed with 6 pounds of flour or 10 of lime and dusted merely enough to show evenly over the surface.

As poisoned bait.—It is not always advisable or effective to apply arsenicals directly to the plants, and this is particularly true in the case of the attacks of the grasshopper and of the various cutworms and wireworms. In such cases the use of poisoned bait has proved very satisfactory.

For locusts, take 1 part, by weight, of white arsenic, 1 of sugar, and 6 of bran, to which add water to make a wet mash. Place a tablespoonful of this at the base of each tree or vine, or apply a line of baits just ahead of the advancing army of grasshoppers, placing a tablespoonful of the mash every 6 or 8 feet, and following up with another line behind the first.

For baiting cutworms and wireworms, distribute poisoned green, succulent vegetation, such as freshly cut clover, in small bunches about in the infested fields. Dip the bait in a very strong arsenical solution, and protect from drying by covering with boards or stones. Renew the bait as often as it becomes dry, or every three to five days. The bran-arsenic bait will also answer for cutworms.

TIME TO SPRAY FOR BITING INSECTS.

For the codling moth, the apple and pear should receive the first application very soon after the blossoms fall, which is also the time for the second treatment of the scab fungus; the second spraying should be

given one or two weeks later, just before the fruit turns down on the stem or when it is from one-fourth to one-half inch in diameter. The first spraying reaches the eggs laid by the moth in the flower end of the fruit shortly after the falling of the blossoms, and the second, the later egg-laying by the more belated moths, when the first coating of poison will probably have been washed off by rains. The young larva, eating its way from without into the fruit, gets enough of the poison to destroy it. This treatment reaches at the same time a large number of leaf-feeding enemies of these fruit trees.

For the curculio of the stone fruits—plum, cherry, peach, etc.—two or three applications should be made; the first as soon as the foliage is well started, the second at the time of the exposure of the young fruit by the falling of the calyx, and perhaps a third a week later, particularly if rains have intervened after the last treatment. The poison here acts to destroy the parent curculio instead of the young larvæ, which, hatching from eggs placed beneath the skin of the fruit, are not affected by the poison on the outside. The adult curculio, however, as soon as it comes from its hibernation, feeds on the foliage before the trees bloom, and later on the young fruit also, and is destroyed by the arsenical before its eggs are deposited.

For leaf-feeding insects in general, such as the Colorado potato-beetle, blister beetles, elm leaf-beetle, maple worm, etc., the application should be made at the earliest indication of injury and repeated as often as necessary.

Fruit trees should never be sprayed when in bloom, on account of the liability of poisoning honeybees or other insects useful as cross fertilizers.

CARE IN USE OF ARSENICALS.

It must be remembered that these arsenicals are very poisonous and should be so labeled. If ordinary precautions are taken there is no danger to man or team attending their application. The wetting of any, which can not always be avoided, is not at all dangerous, on account of the great dilution of the mixture, and no ill effects whatever have resulted from this source. With some individuals the arsenite of lead, when in strong mixture, affects the eyes, but this is unusual and with a little care in spraying the mist need not strike the operator at all.

The poison disappears from the plants almost completely within twenty to twenty-five days, and even if the plants were consumed shortly after the application an impossible quantity would have to be eaten to get a poisonous dose. To illustrate, in the case of the apple, if the entire fruit were eaten, core and all, it would take several barrels at a single sitting to make a poisonous dose (Riley), and with the cabbage, dusted as recommended above, 28 heads would have to be eaten at one meal to reach this result (Gillette). It is preferable, however, to use other insecticides in the case of vegetables soon to be eaten, and thus avoid all appearance of danger.

INSECTICIDES FOR EXTERNAL SUCKING INSECTS (CONTACT POISONS).

The simple remedies for this class of insects, such as soap, insect powder, sulphur, tobacco decoction, etc., are frequently of value, but need little special explanation. Some brief notes will be given, however, describing the methods of using some of these substances which are easily available and will often be of service, particularly where few plants are to be treated. The standard remedies for this group of insects, viz, the kerosene emulsions, resin washes, lime, sulphur, and salt wash, hydrocyanic acid gas, and vapor of bisulphide of carbon will be afterwards treated in the order mentioned.

SOAPS AS INSECTICIDES.

Any good soap is effective in destroying soft-bodied insects, such as plant-lice and young or soft-bodied larvæ. The soaps made of fish oil and sold under the name of whale-oil soaps are often especially valuable, but variable in composition and merits. A soap made with caustic potash rather than with caustic soda, as is commonly the case, should be demanded, the potash soap yielding a liquid in dilution more readily sprayed and more effective against insects.

For plant-lice and delicate larvæ, such as the pear slug, a strength obtained by dissolving half a pound of soap in a gallon of water is sufficient. Soft soap will answer as well as hard, but at least double quantity should be taken.

As winter washes the fish-oil soaps have proved the most effective means of destroying certain scale insects, and have been particularly serviceable against the very resistant San Jose scale. For winter applications the soap is employed at the rate of 2 pounds to the gallon of water, and is applied hot with a spray pump as soon as the leaves fall in the autumn, repeating if necessary in the spring before the buds unfold.

PYRETHRUM, OR INSECT POWDER.

This insecticide is sold under the names of Buhach and Persian insect powder, or simply insect powder, and is the ground-up flowers of the Pyrethrum plant. It acts on insects externally through their breathing pores, and is fatal to many forms both of biting and sucking insects. It is not poisonous to man or the higher animals, and hence may be used where poisons would be objectionable. Its chief value is against household pests, such as roaches, flies, and ants, and in greenhouses, conservatories, and small gardens, where the use of arsenical poisons would be inadvisable.

It is used as a dry powder, pure or diluted with flour, in which form it may be puffed about rooms or over plants. On the latter it is preferably applied in the evening, so as to be retained by the dew. To keep out mosquitoes, and also to kill them, burning the powder in a tent or a room will give satisfactory results.

It may also be used as a spray at the rate of 1 ounce to 2 gallons of water, but in this case should be mixed some twenty-four hours before being applied. For immediate use, a decoction may be prepared by boiling in water from five to ten minutes.

SULPHUR.

Flowers of sulphur is one of the best remedies for plant mites such as the red spider, six-spotted orange mite, rust mite of the citrus fruits, etc. Applied at the rate of 1 ounce to a gallon of water, or mixed with some other insecticide, such as kerosene emulsion, it is a very effective remedy. For the rust mite, sprinkling the sulphur about under the trees is sometimes sufficient in moist climates to keep the fruit bright. Sulphur is often used to rid poultry houses of vermin, and when fed to cattle is said to be a good means of ridding them of lice, or it may be mixed with grease, oil, etc., and rubbed into the skin.

BISULPHIDE OF LIME.

This chemical is even better than sulphur as a remedy for mites. It is a liquid, and can be diluted easily to any extent. It can be made very cheaply by boiling together, in a small quantity of water, equal parts of lime and flowers of sulphur. For mites take 5 pounds of sulphur and 5 pounds of lime, and boil in a small quantity of water until both are dissolved and a brownish liquid results. Dilute to 100 gallons.

PURE KEROSENE.

Kerosene, or coal oil, is occasionally used directly against insects, although its importance as an insecticide is in the combinations with soap and milk described below. Under exceptional conditions it may be sprayed directly on living plants, and it has been so used, even in the growing season, without injury. It is apt, however, even in the dormant season, on leafless plants, to do serious injury or to kill the plant outright. The pure oil should only be applied as a winter wash either in a spray or with a sponge, using the least possible quantity. Its use is not advised save in exceptionally bad cases of infestation and during the dormant period. It is least dangerous to plants on bright, dry, warm days.

Kerosene is now being used to a certain extent, also, mechanically combined with water in the act of spraying, and is less harmful in this way than when used pure, as it is broken up more finely and is better distributed; but the danger to tender plants is not altogether avoided by this means.

Many insects which can not be destroyed by ordinary insecticides, or where it is unsafe to spray the plants themselves, may be killed by jarring them from the plants into pans of water on which a little kerosene is floating, or they may be shaken from the plants upon cloth screens saturated with kerosene, the crude product being preferable for the latter purpose.

As a remedy for the mosquito, kerosene has proved very effective. It is employed to destroy the larvæ of the mosquitoes in their favorite breeding places in small pools, still ponds, or stagnant water; and where such bodies of water are not sources of drinking supply or of value for their fish, especially in the case of temporary pools from rains, which frequently breed very disagreeable local swarms, the use of oil is strongly recommended. The kerosene is applied at the rate of 1 ounce to 15 square feet of water surface. It forms a uniform film over the surface and destroys all forms of aquatic insect life, including the larvæ of the mosquito, and also the adult females coming to the water to deposit their eggs. The application retains its efficiency for several weeks, even with the occurrence of heavy rains.

THE KEROSENE WASHES.

The kerosene and soap emulsion formula.

Kerosene.....	gallons..	2
Whale-oil soap (or 1 quart soft soap).....	pound..	$\frac{1}{2}$
Water.....	gallon..	1

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, the emulsion will keep indefinitely, and should be diluted only as wanted for use.

For the treatment of large orchards or in municipal work requiring large quantities of the emulsion, it will be advisable to manufacture it with the aid of a steam or gasoline engine, as has been very successfully and economically done in several instances, all the work of heating, churning, etc., being accomplished by this means.

The use of whale-oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, and does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft soap answers very well, and 1 quart of it may be taken in lieu of the hard soaps.

In limestone regions, or where the water is very hard, some of the soap will combine with the lime or magnesia in the water and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye, or rain water employed; but better than either, follow the milk emulsion formula, with which the character of the water, whether hard or soft, does not affect the result.

The kerosene and milk emulsion formula.

Kerosene	gallons..	2
Milk (sour)	gallon..	1

Heating is unnecessary in making the milk emulsion, which otherwise is churned as in the former case. The change from a watery liquid to a thick buttery consistency, much thicker than with the soap, takes place very suddenly after three to five minutes' agitation. With sweet milk difficulty will frequently be experienced, and if the emulsion does not result in five minutes, the addition of a little vinegar will induce prompt action. It is better to prepare the milk emulsion from time to time for immediate use, unless it can be stored in quantity in air-tight jars, otherwise it will ferment and spoil after a week or two.

How to use the emulsions.—During the growing period of summer, for most plant-lice and other soft-bodied insects, dilute the emulsion with from 15 to 20 parts of water; for the red spider and other plant mites the same, with the addition of 1 ounce of flowers of sulphur to the gallon; for scale insects, the larger plant-bugs, larvæ, and beetles, dilute with from 7 to 9 parts water; apply with spray pump.

For winter applications to the trunks and larger limbs of trees in the dormant and leafless condition, to destroy scale insects stronger mixtures may be used even to the pure emulsion, which latter can not be sprayed successfully, but may be applied with brush or sponge. Diluted with one or more parts of water it may be applied in spray without difficulty. The use of the pure emulsion is heroic treatment and only advisable in cases of excessive infestation, and in general it is much better and safer to defer the treatment until the young scales hatch in the spring, when the nine-times diluted wash may be used with more certain results and without danger to plants. The winter treatment should be followed by a use of the spring wash to destroy any young which may come from female scales escaping the stronger mixture.

Caution.—In the use of kerosene washes, and, in fact, of all oily washes on plants, the application should be just sufficient to wet the plant, without allowing the liquid to run down the trunk and collect about the crown. Usually at this situation there is a cavity formed by the swaying of the plants in the wind, and accumulation of the insecticide at this point, unless precautions be taken, may result in the death or injury of the plant. It is advisable to mound up the trees before spraying and firmly pack the earth about the bases whenever it is necessary to drench them thoroughly; and care should be taken in refilling the tank that no free oil is allowed to accumulate gradually in the residue left at the bottom.

THE RESIN WASH.

This wash has proved of greatest value in California, particularly against the red scale (*Aspidiotus aurantii*) and the black scale (*Lecanium*

olea') on citrus plants, and the last named and the San Jose scale (*Aspidiotus perniciosus*) on deciduous plants, and will be of use in all similar climates where the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and where, owing to the warmth, the multiplication of the scale insects continues almost without interruption throughout the year. Where rains are liable to occur at short intervals, and in the Northern States, the quicker-acting and stronger kerosene washes and heavy soap applications are preferable. The resin wash acts by contact, having a certain caustic effect, but principally by forming an impervious, smothering coating over the scale insects. The application may be more liberal than with the kerosene washes, the object being to wet the bark thoroughly.

The wash may be made as follows:

Resin.....	pounds..	20
Crude caustic soda (78 per cent).....	do.....	5
Fish oil.....	pints..	2½
Water to make.....	gallons..	100

Ordinary commercial resin is used, and the caustic soda is that put up for soap establishments, in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (98 per cent) used—3½ pounds of the latter being the equivalent of 5 pounds of the former. Place these substances, with the oil, in a kettle with water to cover them to a depth of 3 or 4 inches. Boil about two hours, making occasional additions of water, or until the compound resembles very strong, black coffee. Dilute to one-third the final bulk with hot water, or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed the mixture should be perfectly fluid, without sediment, and should any appear in the stock mixture reheating should be resorted to, and in fact the wash is preferably applied hot.

As a winter wash for scale insects, and particularly for the more resistant San Jose scale (*Aspidiotus perniciosus*), stronger washes are necessary. In southern California, for this latter insect, the equivalent of a dilution one-third less, or 66⅔ gallons instead of 100, has given very good satisfaction. In Maryland, with this insect, it has proved necessary to use the wash at 6 times the summer strength to destroy all of the well-protected hibernating scales; and with other scale insects much stronger mixtures than those used in California have proved ineffectual in the East. For regions, therefore, with moderately severe winters, the use of the resin wash to destroy hibernating scale insects seems inadvisable.

THE LIME, SALT, AND SULPHUR WASH.

This is the almost invariable remedy for the San Jose scale in California, and over much of the State it is undoubtedly very effective. Experience with this wash in the East had thrown doubt on its real

efficiency as an insecticide, and it has been clearly demonstrated that under the climatic conditions east of the Alleghanies it is almost valueless. In California, however, the demonstration of its usefulness against the San Jose scale is complete, and the benefit of its application to orchards is most manifest. In the vicinity of Pomona, Cal., unsprayed orchards are as badly infested with San Jose scale as any of the invaded Eastern orchards are to-day, while in adjoining sprayed orchards the scale is entirely killed and the trees are rapidly recovering and showing vigorous and healthy new growth. In contiguous orchards, also of the same kinds of trees, similarly treated, so far as cultivation is concerned, the trees which have been subjected to yearly spraying are at least one-third larger than untreated trees. This wash is of value also as a fungicide, protecting stone fruits from leaf fungi, and is also a protection against birds, the common California linnet doing great damage to buds in January and February. The wash is almost invariably made and applied by contractors, and costs about 5 cents per gallon applied to the trees. It is a winter application, being applied in January and February.

Along the coast region and in northern California, where moister conditions prevail, this wash is very much less successful, bearing out somewhat the experience of the East, and doubtless explained by the similarity of climate in the districts mentioned with that of the Atlantic seaboard.

In making this wash the chief consideration seems to be prolonged boiling. The wash itself is practically a sulphide of lime, with free lime and salt carried with it. Prolonged boiling will result in taking up, temporarily at least, additional sulphur, and will perhaps add to its caustic properties. The proportions of the ingredients and the method of combining them varies slightly in different sections. The following is the ordinary formula: Unslaked lime, 40 pounds; sulphur, 20 pounds; salt, 15 pounds; one-fourth of the lime is first slaked and boiled with the sulphur in 20 gallons of water for two or three hours; the remainder of the lime is slaked and together with the salt is added to the hot mixture and the whole boiled for a half hour or an hour longer. Water is then added to make 60 gallons of wash. This wash is applied practically every year, or as often as the San Jose scale manifests itself in any numbers. In the coast region and in the northern part of California it is necessary to apply it with greater frequency than in the interior districts.

TIME TO SPRAY FOR SUCKING INSECTS.

For the larger plant-bugs and the aphides, or active plant-lice, and all other sucking insects which are present on the plants injuriously for comparatively brief periods, or at most during summer only, the treatment should be immediate, and if in the form of spray on the plants, at a strength which will not injure growing vegetation.

For scale insects and some others, as the pear *Psylla*, which hibernate on the plants, two or more strengths are advised with most of the liquid insecticides recommended, the weaker for summer applications and the more concentrated as winter washes. The summer washes for scale insects are most effective against the young, and treatment should begin with the first appearance of the larvæ of the spring or any of the later broods, and should be followed at intervals of seven days with two or three additional applications. The first brood, for the majority of species in temperate regions, will appear during the first three weeks in May. Examination from time to time with a hand lens will enable one to determine when the young of any brood appear.

The winter washes may be used whenever summer treatment can not be successfully carried out, and are particularly advantageous in the case of deciduous plants with dense foliage which renders a thorough wetting difficult in summer, or with scale insects which are so irregular in the time of disclosing their young that many summer treatments would be necessary to secure anywhere near complete extermination. In the winter also, with deciduous trees, very much less liquid is required, and the spraying may be much more expeditiously and thoroughly done. In the case of badly infested trees, a vigorous pruning is advisable as a preliminary to treatment.

As winter washes for temperate regions the kerosene mixtures and whale-oil soap solutions, particularly the latter, have so far given the best results. These stronger mixtures may be applied at any time during the dormant period of vegetation, and, with deciduous trees, preferably immediately after the falling of the foliage. In the growing season any of these stronger washes would cause the loss of foliage and fruit, and the more concentrated probably the death of the plant.

THE GAS TREATMENT.

Hydrocyanic acid gas.

The use of hydrocyanic acid gas originated in California, and was perfected by a long period of experimentation by an agent of this division, Mr. D. W. Coquillett. It has not been followed to any extent elsewhere, however; but in southern California it is held to be the best treatment for citrus trees and is now better understood and more satisfactory than ever before. It is especially applicable to citrus trees, the abundance of foliage and nature of the growth of which enables comparatively heavy tents to be thrown over them rapidly without danger of breaking the limbs. With deciduous trees it has not been practicable to use this gas to any extent, except in the case of nursery stock, which may be brought together compactly and treated in mass under tents. This gas is also the principal agency employed in disinfecting material coming into California from abroad. Recently it has been introduced into the East, more particularly to combat the San Jose scale and as a means of disinfecting nursery stock.

Treatment consists in inclosing a tree (or nursery stock in greater or less quantities at once) with a tent and filling the latter with the poisonous fumes generated with potassium cyanide and sulphuric acid.

For nursery stock, in place of a tent it is often more convenient and desirable to provide one or more fumigating boxes or small fumigating houses.

The proportions of chemicals for growing plants are as follows: Refined potassium cyanide (98 per cent), 1 ounce; commercial sulphuric acid, 1 fluid ounce; and 3 fluid ounces of water to every 150 cubic feet of space inclosed. The generator may be any glazed earthenware vessel of 1 or 2 gallons capacity, and is placed on the ground within the tent or on the floor of the fumigating chamber, and the water, acid, and cyanide, the latter in large lumps, added in the order named.

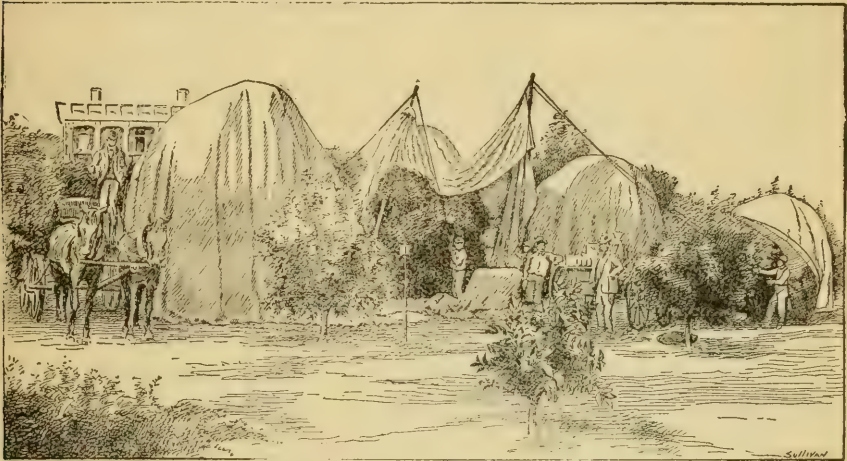


FIG. 1.—Tenting trees for gas treatment. San Diego, Cal. (author's illustration).

Treatment should continue forty minutes, and for growing plants should be practiced only on cloudy days or at night, the danger of injury to foliage or tender growth being much greater in sunlight.

The table given below applies to citrus trees in southern California; in the winter treatment of nursery stock or deciduous orchards, a much greater strength can be employed if found necessary.

Height of tree (feet).	Diameter through foliage (feet).	Water (fluid ounces).	Sulphuric acid (fluid ounces).	Cyanide potassium (ounces).
6	4	1	$\frac{1}{2}$	$\frac{1}{2}$
8	6	$2\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{4}$
10	8	$3\frac{1}{2}$	2	2
12	10	6	3	3
12	14	9	$4\frac{1}{2}$	$4\frac{1}{2}$
14	14	10	5	5
16	16	12	$5\frac{1}{2}$	$5\frac{1}{2}$
18	16	12	6	6
20	16	13	$6\frac{1}{2}$	$6\frac{1}{2}$

The old statement that less time is required for small trees or plants than for larger ones is found to be an error, and, in fact, it is reasonable that an insect is no more easily killed on a small plant than on a large one. In the application of gas to growing plants it should be used at a strength as great as the tree can stand, and, in fact, the tender terminals should be slightly scalded, which is proof that the gas is of proper strength. Treatment of this character is necessary to destroy the more resistant scales. For very compact trees with dense foliage from one-fourth to one-third more gas should be generated, and this is true also of the moister coast regions, or within 10 miles of the coast in the West and for winter work on dormant plants in the East. In the case of young trees and nursery stock in foliage there is much less danger of scalding if the gas be generated slowly, either by employing a greater amount of water or using the cyanide in large lumps.

Trees are fumigated for the black scale in southern California in October, or preferably in November, the young black scales in this part of the State having usually all emerged by October 1. After the black scale has abandoned the leaves and gone back to the twigs and fixed itself firmly, the gas is not so effective against it. The red and other scales may be treated with gas at any time, but preferably at the season already alluded to. In California most of the work is done by contract, or under the direct supervision of the county horticultural commissioners, in some cases the tents and material being furnished at a mere nominal charge, together with one experienced man to superintend the work, while a crew of four men operate the tents, the wages of the director and men being paid by the owner of the trees.

The tents now employed are of two kinds, the "sheet" tent of octagonal shape for large trees, and the "ring" tent for trees under 12 feet in height. The ring tents, or, as they are also called, the bell tents, are bell-shaped and have a hoop of half-inch gas pipe fastened within a foot or so of the opening. Two men can easily throw one of these tents over a small tree. An equipment of 36 or 40 ring tents can be handled by four men. They are rapidly thrown over the trees by the crew, and the director follows closely and introduces the chemicals. By the time the last tent has been adjusted the first one can be removed and taken across to the adjoining row. An experienced crew, with one director, can treat 350 to 400 five-year-old trees, averaging in height 10 feet, in a single night of eleven or twelve hours. The cost under such conditions averages about 8 cents a tree.

With large trees the large sheet tents are drawn over them by means of uprights and pulley blocks. Two of these sheets* are necessary for very large trees, the first being drawn halfway over and the second drawn up and made to overlap the first. In the case of trees from 24

to 30 years old and averaging 30 feet in height, about 50 can be treated in a night of ten or twelve hours, with an equipment of 12 or 15 tents, the cost being about 75 cents per tree. It is not practicable to treat trees above 30 feet in height.

The handling of the bell tents is simple and needs no further description, but the large tents are not so easily operated, and the method of adjusting the great flat octagonal sheets over the trees, while simple

enough when once understood, will have, perhaps, some interest for Eastern fruit growers who may desire to experiment with the hydrocyanic acid gas. The only machinery employed consists of two simple up-rights, with attached blocks and tackle (fig. 2). The up-rights are about 25 feet high, of strong Oregon pine, 2 by 4 inches, and are provided at the bottom with a braced cross-bar to give them strength and to prevent their falling to either side while the tent is being raised. A guy rope is attached to the top of each pole and held to steady it by two of the crew stationed at the rear of the tree. The tent is hoisted by means of two ropes 70 feet long, which pass through blocks, one fixed at the top of the pole and the other free. The tent is caught near the edge by taking a hitch around some solid object, such as a green orange, about which the cloth is gathered. By this means the tent may be caught anywhere without the trouble

of reversing and turning the heavy canvas to get at rings or other fastenings attached at particular points. The two remaining members of the operating crew draw the tent up against and over one side of the tree by means of the pulley ropes sufficiently to cover the other side of the tree when the tent falls. The poles and tent together are then allowed to fall forward, leaving the tent in position. Sufficient skill is soon acquired to carry out rapidly the details of this operation, so that

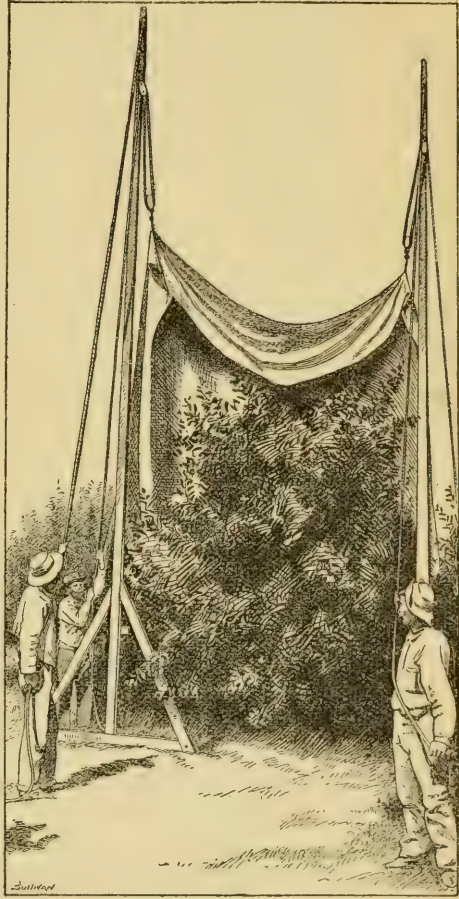


FIG. 2.—Method of hoisting sheet tent (after Craw).

little time is lost in transferring the tents from tree to tree, even when the trees approximate the limit in height. A single pair of hoisting poles answers for all the tents used.

Some practical experience is necessary to fumigate successfully, and it will therefore rarely be wise for anyone to undertake it on a large scale without having made preliminary experiments. If the cyanide treatment is to be introduced in the East, it would be well for fruit growers to obtain the services for a year or more of an experienced man from California to give them a practical illustration of methods, and even in California it is recognized that such work is much more economically accomplished when given over to experienced persons and done under contract. The gas treatment is probably the most thorough of all methods, but complete extermination is very rare. Fumigation must therefore be repeated every two or three years, or as often as the scale insects reappear in any numbers.

The canvas for the tents, blue or brown drilling or 8-ounce duck, may be rendered comparatively impervious to the gas by painting lightly with boiled linseed oil. This has the objection, however, of stiffening the fabric and adding considerably to its weight; it also frequently leads to its burning by spontaneous combustion unless carefully watched until the oil is dry. A much better material than oil is found in a product obtained from the leaves of the common prickly pear cactus (*Opuntia engelmanni*), which grows in abundance in the Southwest. The liquor is obtained by soaking chopped-up leaves in water for twenty-four hours. It is given body and color by the addition of glue and yellow ocher or Venetian red, and is applied to both sides of the canvas and rubbed well into the fiber of the cloth with a brush.

Bisulphide of carbon vapor.

In line with the use of hydrocyanic acid gas is the employment of the vapor of bisulphide of carbon to destroy insects on low-growing plants, such as the lice on melon and squash vines. The treatment, as successfully practiced by Professors Garman and Smith, consists in covering the young vines with small tight boxes 12 to 18 inches in diameter, of either wood or paper, and introducing under each box a saucer containing one or two teaspoonfuls (1 or 2 drams) of the very volatile liquid, bisulphide of carbon. The vines of older plants may be wrapped about the hill and gathered in under larger boxes or tubs, and a greater, but proportional, amount of bisulphide used. The covering should be left over the plants for three-quarters of an hour to an hour, and with 50 to 100 boxes a field may be treated with comparative rapidity.

DUSTING AND SPRAYING APPARATUS.

For the application of powders the dusting bags already described are very satisfactory, or for garden work some of the small powder bellows and blowers are excellent. The best of these cost about \$2 each and are on the market in many styles.

Better apparatus is required for the wet applications where successful results require the breaking up of the liquid into a fine mist-like spray. The essential features of such an apparatus are a force pump, several yards of one-half inch cloth-reinforced hose with bamboo hoisting rod, and a spray tip. The size of the apparatus will depend on the amount of vegetation to be treated. For limited garden work and for the treatment of low plants the knapsack pumps or the small bucket force pumps are suitable, the former costing about \$14 and the latter from \$6 to \$9.

Ready fitted pumps, knapsack and others, for the application of insecticides, are now made by all the leading pump manufacturers of this country, and also large reservoirs with pump attached for extended orchard operations, the price of the latter ranging from \$25 to \$75.

The cost of a spraying outfit for orchard work may be greatly reduced by combining a suitable pump and fixtures with a home-constructed tank or barrel, to be mounted on a cart or wagon. A spray tank having a capacity of about 150 gallons is a very satisfactory size, and may be conveniently made 4 feet long by $2\frac{1}{2}$ wide by 2 deep, inside measurements. It should be carefully constructed, so as to be water-tight, and should be strengthened by four iron bolts or rods across the ends, one each at the top and bottom. A good double-acting force pump may be obtained from any of the leading pump manufacturers at a cost of from \$10 to \$20, depending upon whether of iron or brass, and the nature of its fittings. For use in very large orchards or in city parks it may be advisable to construct the tank of twice the capacity mentioned, to expedite the spraying and to avoid the more frequent refillings necessary with the smaller tank.

For the requirements last mentioned the use of power spraying apparatus of considerable capacity has become somewhat general, particularly in municipal work against shade tree insects in the East, and in spraying the large citrus groves of the Pacific Slope. An apparatus of this sort recently built by the Division of Entomology of the Department is illustrated in the accompanying figure (fig. 3). The use of power apparatus for spraying is a special subject, and those interested would do well to consult the article by Dr. L. O. Howard (Yearbook Dept. Agric., 1896, pp. 69-88) giving full descriptive details, with figures, of the important machines now in use.

The more economical spray tips in the amount of liquid required are the different styles of cyclone nozzles, the best form of which is known to the market generally as the Vermorel nozzle. These are manufactured by the leading spray pump companies. Other good nozzles are also on the market. The common garden spraying and hose nozzles are much too coarse for satisfactory work, and are wasteful of the liquid.

A prime essential in spraying, especially where the large reservoirs are employed, is to keep the liquid constantly agitated to prevent the

settling of the poison to the bottom of the tank. This may be accomplished by constant stirring with a paddle, by shaking, but preferably by throwing a stream of the liquid back into the tank. Many of the larger pumps are now constructed with two discharge orifices with this latter object in view or are provided with special agitators, and the use of such is recommended.

For fruit trees of average size, or if apple, such as would produce from 10 to 15 bushels of fruit, from 3 to 7 gallons of spray are necessary to wet each tree thoroughly. For smaller trees, such as plum and cherry, 1 gallon to the tree will be sufficient. If an average of 5 gallons to the tree be taken for an apple orchard of 1,000 trees, 5,000

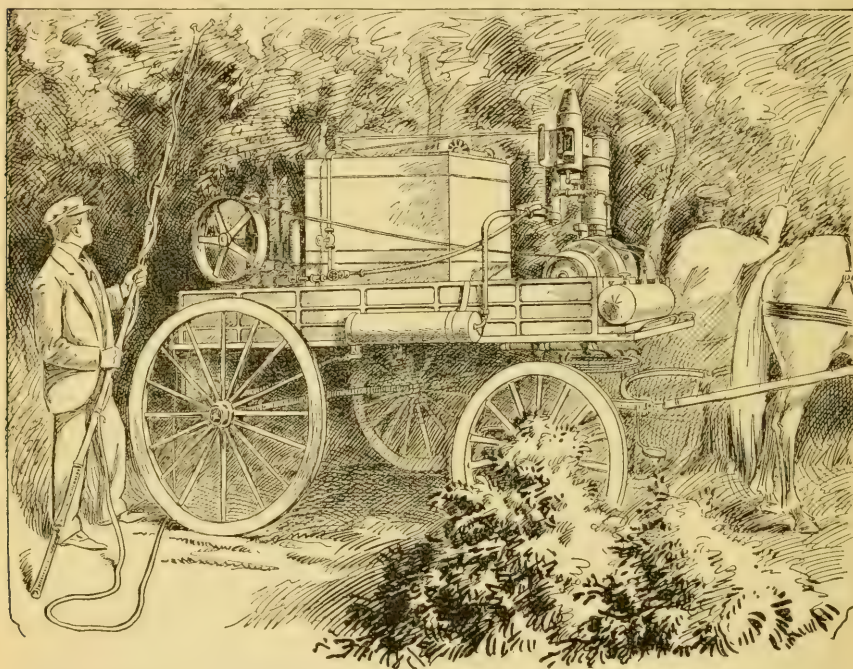


FIG. 3.—Gasoline power-spraying outfit of the Division of Entomology, U. S. Department of Agriculture (author's illustration).

gallons of spray would be required. About 33 pounds of Paris green or London purple would be needed for one spraying if used at the rate of 1 pound to 150 gallons of water, and for the two applications ordinarily recommended 66 pounds. This, for the Paris green, at 20 cents a pound, would amount to \$13.20, and the London purple, at 10 cents a pound, to \$6.60, or a little over 1 cent a tree for the former and one-half a cent for the latter.

In spraying orchard trees it will be found convenient in going between the rows to spray on each side, half of each tree in the row at a time and finish on the return, rather than attempt to spray all sides of one tree before taking up another.

The object in spraying is to coat every leaf and part of the plant as lightly as compatible with thoroughness, and to avoid waste in doing this a mist spray is essential. The application to any part should stop when water begins to drip from the leaves. A light rain will not remove the poison, but a dashing one will probably necessitate a renewal of the application.

REMEDIES FOR SUBTERRANEAN INSECTS.

Almost entire dependence is placed on the caustic washes, or those that act externally, for insects living beneath the soil on the roots of plants, including both sucking and biting insects, prominent among which are the white grubs, maggots in roots of cabbage, radishes, onions, etc., cutworms, wireworms, apple and peach root-lice, the grape phylloxera, and many others.

The insecticide must be one that will go into solution and be carried down by water. Of this sort are the kerosene emulsions and resin wash—the former preferable—the potash fertilizers, muriate and kainit, and bisulphide of carbon. The simple remedies are in applications of strong soap or tobacco washes to the soil about the crown; or soot, ashes, or tobacco dust buried about the roots; also similarly employed are lime and gas lime. Submersion, wherever the practice of irrigation or the natural conditions make it feasible, has also proved of the greatest service against the phylloxera.

HOT WATER.

As a means of destroying root-lice, and particularly the woolly louse of the apple, the most generally recommended measure hitherto is the use of hot water, and this, while being both simple and inexpensive, is thoroughly effective, as has been demonstrated by practical experience. Water at nearly the boiling point may be applied about the base of young trees without the slightest danger of injury to the trees, and should be used in sufficient quantity to wet the soil thoroughly to a depth of several inches, as the lice may penetrate nearly a foot below the surface. To facilitate the wetting of the roots and the extermination of the lice, as much of the surface soil as possible should be first removed.

By a hot-water bath slightly infested stock can easily be freed of the aphides at the time of its removal from the nursery rows. The soil should be dislodged and the roots pruned, and in batches of a dozen or so the roots and lower portion of the trunk should be immersed for a few seconds in water kept at a temperature of 130° to 150° F. A strong soap solution similarly heated or a fifteen times diluted kerosene emulsion will give somewhat greater penetration and be more effective, although the water alone at the temperature named should destroy the lice.

Badly infested nursery stock should be destroyed, since it would be worth little even with the aphides removed.

TOBACCO DUST.

Some recent very successful experiments conducted by Mr. J. M. Stedman have demonstrated the very satisfactory protective as well as remedial value of finely ground tobacco dust against the woolly aphis. The desirability of excluding the aphis altogether from nursery stock is at once apparent, and this Mr. Stedman has shown to be possible by placing tobacco dust freely in the trenches in which the seedlings or grafts are planted and in the orchard excavations for young trees. Nursery stock may be continuously protected by laying each spring a line of the dust in a small furrow on either side of the row and as close as possible to the tree, covering loosely with earth. For large trees, both for protection and the destruction of existing aphides, from 2 to 5 pounds of the dust should be distributed from the crown outward to a distance of 2 feet, first removing the surface soil to a depth of from 4 to 6 inches. The tobacco kills the aphides by leaching through the soil, and acts as a bar for a year or so to reinfestation. The dust is a waste product of tobacco factories, costs about 1 cent per pound, and possesses the additional value of being worth fully its cost as a fertilizer.

KEROSENE EMULSION AND RESIN WASH.

Either the kerosene and soap emulsion or the resin wash, the former diluted 15 times and the latter at the strength of the winter mixture, are used to saturate the soil about the affected plants and either left to be carried down by the action of rains or washed down to greater depths by subsequent waterings.

For the grape phylloxera or the root-louse of the peach or apple, make excavations 2 or 3 feet in diameter and 6 inches deep about the base of the plant and pour in 5 gallons of the wash. If not a rainy season, a few hours later wash down with 5 gallons of water and repeat with a like amount the day following. It is better, however, to make this treatment in the spring, when the more frequent rains will take the place of the waterings.

For root-maggots enough of the wash is put along at the base of the plant to wet the soil to a depth of 1 to 2 inches, preferably followed after an hour with a like amount of water.

For white grubs in strawberry beds or in lawns the surface should be wetted with kerosene emulsion to a depth of 2 or 3 inches, following with copious waterings to be repeated for two or three days. The larvae go to deeper and deeper levels and eventually die.

POTASH FERTILIZERS.

For white grubs, wireworms, cutworms, corn root-worms, and like insects, on the authority of Prof. J. B. Smith, either kainit or the muriate of potash, the former better, are broadcasted in fertilizing quantities, preferably before or during a rain, so that the material is

dissolved and carried into the soil at once. These not only act to destroy the larvæ in the soil, but are deterrents, and truck lands constantly fertilized by these substances are noticeably free from attacks of insects. This, in a measure, results from the increased vigor and greater resistant power of the plant, which of itself more than compensates for the cost of the treatment. The value of these fertilizers against the wireworms is, however, questioned by Prof. J. H. Comstock.

For the root-louse of peach and apple, work the fertilizer into the general surface of the soil about the trees, or put it in a trench about the tree 2 feet distant from the trunk.

For cabbage and onion maggots apply in little trenches along the roots at the rate of 300 to 500 pounds to the acre, and cover with soil.

These fertilizers (and the nitrate of soda is nearly as good) are also destructive to the various insects which enter the soil for hibernation or to undergo transformation.

BISULPHIDE OF CARBON.

This is the great French remedy for the phylloxera, 150,000 acres being now subjected to treatment with it, and applies equally well to all other root-inhabiting lice. The treatment is made at any season except the period of ripening of the fruit, and consists in making holes about the vines 1 foot to 16 inches deep and pouring into each about one-half ounce of bisulphide, and closing the hole with the foot. These injections are made about $1\frac{1}{2}$ feet apart, and not closer to the vines than 1 foot. It is better to make a large number of small doses than a few large ones. Hand injectors and injecting plows are employed in France to put the bisulphide into the soil about the vines, but a short stick or iron bar may be made to take the place of these injectors for limited tracts.

The use of bisulphide of carbon for the woolly aphis is the same as for the grape root-louse. It should be applied in two or three holes about the tree to a depth of 6 to 12 inches and not closer than $1\frac{1}{2}$ feet to the crown. An ounce of the chemical should be introduced into each hole, which should be immediately closed.

For root-maggots a teaspoonful is poured into a hole near the base of the plant, covering as above.

For ant nests an ounce of the substance is poured into each of several holes made in the space occupied by the ants, the openings being then closed; or the action is made more rapid by covering with a wet blanket for ten minutes and then exploding the vapor at the mouth of the holes with a torch, the explosion driving the fumes more thoroughly through the soil.

SUBMERSION.

This very successful means against the phylloxera is now practiced over some 75,000 acres of vineyards in France which were once destroyed by the grape root-louse, and the production and quality of fruit has been fully restored. In this country it will be particularly available

in California and in all arid districts where irrigation is practiced; otherwise it will be too expensive to be profitable. The best results are secured in soils in which the water will penetrate rather slowly, or from 6 to 18 inches in twenty-four hours; in loose, sandy soils it is impracticable on account of the great amount of water required. Submersion consists in keeping the soil of the vineyard flooded for from eight to twenty days after the fruit has been gathered and active growth of the vine ceased, or during September or October, but while the phylloxera is still in active development. Early in September eight to ten days will suffice; in October, fifteen to twenty days, and during the winter, as was formerly practiced, forty to sixty days. Supplementing the short fall submergence a liberal July irrigation, amounting to a forty-eight-hour flooding, is customary to reach any individuals surviving the fall treatment, and which in midsummer are very susceptible to the action of water.

To facilitate the operation, vineyards are commonly divided by embankments of earth into square or rectangular plots, the former for level and the latter for sloping ground, the retaining walls being protected by coverings of reed grass, etc., during the first year, or until they may be seeded to some forage plant.

This treatment will destroy many other root-attacking insects and those hibernating beneath the soil, and, in fact, is a very ancient practice in certain oriental countries bordering the Black Sea and the Grecian Archipelago.

REMEDIES FOR INSECTS AFFECTING GRAIN AND OTHER STORED PRODUCTS.

GENERAL METHODS OF TREATMENT.

The chief loss in this direction from insects is to grains in farmers' bins, or grain or grain products in stores, mills, and elevators, although in the warmer latitudes much of the injury results from infestation in the field between the ripening of the grain and its storage in bins or granaries. Fortunately, the several important grain insects are amenable to like treatment. Aside from various important preventive considerations, such as, in the South, prompt threshing of grain after harvesting, the thorough cleansing of bins before refilling, constant sweeping, removal of waste harboring insects from all parts of granaries and mills, and care to prevent the introduction of "weeviled" grain, there are three valuable remedial measures, viz, agitation of the grain, heating, and dosing with bisulphide of carbon.

The value of agitating or handling grain is well known, and whenever, as in elevators, grain can be transferred or poured from one bin into another grain pests are not likely to trouble. The benefit will depend upon the frequency and thoroughness of the agitation, and in France machines for shaking the grain violently have been used with

success. Winnowing weeviled grain is also an excellent preliminary treatment.

Raising the temperature of the grain in closed retorts or revolving cylinders to 130° to 150° F. will kill the inclosed insects if continued for from three to five hours, but is apt to injure the germ, and is not advised in case of seed stock. The simplest, cheapest, and most effectual remedy is the use of bisulphide of carbon.

BISULPHIDE OF CARBON.

This is a colorless liquid with very offensive odor, which, however, passes off completely in a short time. It readily volatilizes and the vapor, which is very deadly to insect life, is heavier than air and settles and fills any compartment or bin in the top of which the liquid is placed. It may be distributed in shallow dishes or tins or in saturated waste on the top of grain in bins, and the gas will settle and permeate throughout the mass of the grain. In large bins, to hasten and equalize the operation, it is well to put a quantity of the bisulphide in the center of the grain by thrusting in balls of cotton or waste tied to a stick and saturated with the liquid, or by means of a gas pipe loosely plugged at one end, down which the liquid may be poured and the plug then loosened with a rod. Prof. H. E. Weed reports that in Mississippi the chemical is commonly poured directly onto the grain. In moderately tight bins no further precaution than to close them well need be taken, but in open bins it will be necessary to cover them over with a blanket to prevent the too rapid dissipation of the vapor. The bins or buildings should be kept closed from twenty-four to thirty six hours, after which a thorough airing should be given them.

Limited quantities at a time may often be advantageously subjected to treatment in small bins before being placed for long storage in large masses, and especially whenever there is danger of introducing infested grain.

The bisulphide is applied at the rate of 1 pound to the ton of grain, or a pound to a cubic space 10 feet on a side.

In the case of mills, elevators, or larger granaries the application may be best made on Saturday night, leaving the building closed over Sunday, with a watchman without to see that no one enters, and to guard against fire. The bisulphide should be first distributed in the lower story, working upward to avoid the settling vapor, using the substance very freely, in waste or dishes, at all points of infestation and over bins throughout the building.

This insecticide may also be used in other stored products, as pease, beans, etc., and very satisfactorily where the infested material can be inclosed in a tight can, chest, or closet for treatment.

The bisulphide costs, in 50-pound cans, 10 cents per pound, and in small quantities, of druggists, 25 to 35 cents per pound.

Caution.—The bisulphide may be more freely employed with milling

grain than that intended for seeding, since when used excessively it may injure the germ. It must always be remembered that the vapor is highly inflammable and explosive, and that no fire or lighted cigars, etc., should be in the building during its use. If obtained in large quantities it should be kept in tightly closed vessels and away from fire, preferably in a small outbuilding.

GENERAL CONSIDERATIONS ON THE CONTROL OF INSECTS.

ADVANTAGE OF PROMPT TREATMENT.

The importance of promptness in the treatment of plants attacked by insects can not be too strongly insisted upon. The remedy often becomes useless if long deferred, the injury having already been accomplished or gone beyond repair. If, by careful inspection of plants from time to time, the injury can be detected at the very outset, treatment is comparatively easy and the result much more satisfactory. Preventive work, therefore, should be done as much as possible, rather than waiting for the remedial treatment later; the effort being to forestall any serious injury rather than to patch up damage which neglect has allowed to become considerable.

KILLING INSECTS AS A PROFESSION.

It may often happen that the amount of work in a community is sufficient to induce one or more persons to undertake the treatment of plants at a given charge per tree or per gallon of the insecticide employed. Where this is the case, and the contracting parties are evidently experienced and capable, it is frequently more economical in the end to employ such experienced persons, especially when a guarantee is given, rather than attempt to do the work one's self with the attending difficulty of preparing insecticides and securing apparatus for work on a comparatively small scale. In California this is a common practice, and also in some of our Eastern cities, and has worked excellently.

THE DETERMINATION OF THE RESULT OF TREATMENT.

It is often of importance to know when and how to determine the effect of any treatment applied directly to insects exposed on the surface of plants. In the case of scale insects, especially during the dormant condition in winter, the response to insecticides is very slow and gradual. The scale larvæ, or any young scales during the growing season, are killed in a few minutes, or a few hours at the furthest, just as any other soft-bodied insect, but the mature scale does not usually exhibit the effects of the wash for some time. Little can be judged, ordinarily, of the ultimate results before two weeks, and it is often necessary to wait two months to get final conclusions. The slow, progressive death of the scales is apparently due to the gradual penetra-

tion of the insecticide, and also to the softening and loosening of the scale itself, enabling subsequent weather conditions of moisture and cold to be more fatal.

With such biting insects as caterpillars and slug worms after treatment with arsenicals or other poisons death rapidly follows, the time being somewhat in proportion to the size of the larvæ and their natural vigor. Soft-bodied larvæ, such as the slug worms and very young larvæ of moths and beetles or other insects, are killed in a day or two. Large and strong larvæ sometimes survive the effect of poison for eight or ten days, and leaf-feeding beetles will often fly away and perish from the poison in their places of concealment.

Many larvæ or other forms of leaf-feeding insects, after taking one or two meals of poisoned foliage, will remain in a semitorpid and diseased condition on the plants for several days before they finally succumb. The protection to the plant, however, is just as great as though they had died immediately, but misapprehension may often arise and the poison may be deemed to have been of no service.

The complete extermination of insects on plants is often a very difficult, if not an impossible, undertaking. This is especially true of scale insects. In California even, where the work against these enemies of fruits has been most thorough and successful, experience has shown that the best that can be done is a practical elimination of the scale for the time being, and it is often necessary to repeat the treatment every year or two. In exceptional cases once in three years suffices. With leaf-feeding insects it is often possible to effect complete extermination with the use of arsenical poisons. Such sucking insects as plant-lice may also be completely exterminated. But in general all applications or methods of treatment must be recognized, more or less, as a continuous charge on the crop, as much so as are the ordinary cultural operations.

CONTROL OF INSECTS BY CULTURAL METHODS.

It is much easier to ward off an attack of insects or to make conditions unfavorable for their multiplication than to destroy them after they are once in possession; and in controlling them, methods and systems of farm and orchard culture have long been recognized as of the greatest value, more so even than the employment of insecticides, which, in most cases, can only stop an injury already begun. Insects thrive on neglect, multiply best in land seldom or never cultivated, and winter over in rubbish, prunings, or the undisturbed soil about their food plants, and become, under these conditions, more numerous every year. It is a fact of common observation that it is the neglected farm, vineyard, or orchard filled with weeds or wild growth which is certain to be stocked with all the principal insect enemies; and, on the other hand, thorough and constant culture, with the removal and burning of prunings, stubble, and other waste, the collection and destruction of fallen and diseased fruit, and the practice, where possible,

of fall plowing to disturb the hibernating quarters of field insects, will almost certainly be accompanied by comparative immunity from insect pests.

The vigor and healthfulness of plant growth has also much to do with freedom from insect injury, such plants seeming to have a native power of resistance which renders them, in a measure, distasteful to most insects, or at least able to throw off or withstand their attacks. A plant already weakened, however, or of lessened vitality from any cause, seems to be especially sought after, is almost sure to be the first affected, and furnishes a starting point for general infestation. Anything, therefore, which aids good culture in keeping plants strong and vigorous, such as the judicious use of fertilizers, will materially assist in preventing injury.

To the constant cropping of large areas of land year after year to the same staple is largely due the excessive loss from insects in this country as compared with European countries, because this practice furnishes the best possible conditions for the multiplication of the enemies of such crops. A most valuable cultural means, therefore, is a system of rotation of crops which will prevent the gradual yearly increase of the enemies of any particular staple by the substitution every year or two of other cultures not subject to the attacks of the insect enemies of the first.

With such insects as the Hessian fly, the squash borers, and many others which have regular times of appearance, much can be done, also, by the planting of early or late varieties, or by deferring seeding so as to avoid the periods of excessive danger. Wherever possible, varieties should be selected which experience has shown to be resistant to insect attack. Familiar illustrations of such resistant varieties in all classes of cultivated plants will occur to every practical man, and a better instance of the benefit to be derived from taking advantage of this knowledge can not be given than the almost universal adoption of resistant American vines as stocks for the regeneration of the vineyards of France destroyed by the phylloxera and for the similarly affected vineyards of European grapes in California.

In the case of stored grain pests, particularly the Angoumois moth, or so-called fly weevil, the chief danger in the South is while the grain is standing in shock or stack, after harvesting, during which period the insects have easy access to it. This source of infestation may be avoided by promptly threshing grain after harvesting and storing it in bulk. This will prevent the injury of more than the surface layer, as the insects are not likely to penetrate deeply into the mass of the grain.

These general notes are by no means new, but their importance justifies their repetition, as indicating the best preventive measures in connection with the remedial ones already given.

The overwhelming experience of the past dozen years makes it almost unnecessary to urge, on the ground of pecuniary returns, the adoption of the measures recommended in the foregoing pages against insects. To emphasize the value of such practice, it is only necessary to call attention to the fact that the loss to orchard, garden, and farm crops frequently amounts to from 15 to 75 per cent of the entire product, and innumerable instances could be pointed out where such loss has been sustained year after year, while now, by the adoption of remedial measures, large yields are regularly secured with an insignificant expenditure for treatment. It has been established that in the case of the apple crop spraying will protect from 50 to 75 per cent of the fruit which would otherwise be wormy, and that in actual marketing experience the price has been enhanced from \$1 to \$2.50 per barrel, and this at a cost of only about 10 cents per tree for labor and material.

In the case of one orchard in Virginia, only one-third of which was sprayed, the result was an increase in the yield of sound fruit in the portion treated of nearly 50 per cent, and an increase of the value of this fruit over the rest of 100 per cent. The loss from not having treated the other two-thirds was estimated at \$2,500. The saving to the plum crop and other small fruits frequently amounts to the securing of a perfect crop where otherwise no yield whatever of sound fruit could be secured.

An illustration, in the case of field insects, may also be given where, by the adoption of a system of rotation, in which oats were made to alternate with corn, the owner of a large farm in Indiana made a saving of \$10,000 per year, this amount representing the loss previously sustained annually from the corn root-worm. The cotton crop, which formerly in years of bad infestation by the leaf-worm was estimated to be injured to the extent of \$30,000,000, is now comparatively free from such injury, owing to the general use of arsenicals.

Facts of like import could be adduced in regard to many other leading staples, but the foregoing are sufficient to emphasize the money value of intelligent action against insect enemies, which, with the present competition and diminishing prices, may represent the difference between a profit and a loss in agricultural operations.

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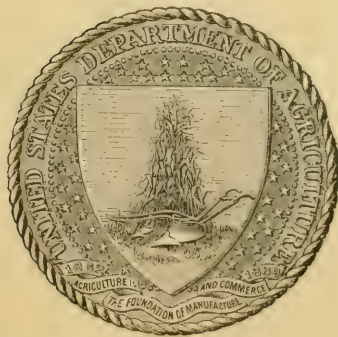
FARMERS' BULLETIN No. 45.

SOME INSECTS INJURIOUS TO STORED GRAIN.

BY

F. H. CHITTENDEN,
ASSISTANT ENTOMOLOGIST.

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SOME INSECTS INJURIOUS TO STORED GRAIN.

Stored grain is subject to injury by insects of several kinds, popularly termed "weevil." Upward of two score of species occur commonly in granaries, three living throughout their adolescent stages within the kernel of the grain. These three are the granary weevil, rice weevil, and Angoumois grain moth, the most injurious forms, both at home and abroad. The remaining species live on grain in the kernel, also when manufactured into flour and meal, and feed as well on various other edible products; hence, though of comparatively little importance as the authors of primary injury to the seed, they are very frequently the cause of serious damage to manufactured products and to grain that has suffered first from the attacks of the weevils or grain moth and has been kept for a length of time in store.

Nearly all of the grain-feeding species known in the United States have been introduced and are now cosmopolitan, having been distributed by commerce to all quarters of the earth, no insects being more easily carried from one land to another, since they breed continuously for years in the same grain and are unknowingly transported when in an immature state in the kernels. Most of our indoor insects are indigenous to the Tropics and do not thrive in the cold climate of our extreme northern States, but in the South they have become acclimated and there do their greatest damage.

NATURE AND EXTENT OF DAMAGE.

Aside from the loss in weight occasioned by the ravages of insects, grain infested by them is unfit for human consumption, and has been known to cause serious illness. Nor is such grain desirable for food for live stock or for seed, its use in the latter capacity being apt to be followed by a diminution in the yield of a crop.

Of the insect injury to stored grain it has been estimated of Texas alone that there is an annual loss of over a million dollars, and that nearly 50 per cent of the corn of that State is annually destroyed by weevils and rats. The loss from granary insects to the corn crop in Alabama in 1893 was estimated at \$1,671,382, or about 10 per cent.

There are seven other States subject to the same atmospheric and other influences as Alabama and producing in the aggregate a somewhat larger average yield of corn. Estimating the annual loss in the same proportions, we would have for these eight Southern States, viz: South

Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, and Arkansas, a total of nearly \$20,000,000. This is for corn alone, and does not take into consideration wheat and other grains or mill products.

In regard to the susceptibility of different grains to "weevil" attack, it may be said that unhusked rice, oats, and buckwheat are practically exempt, but the hull of barley offers less protection to the seed. Husked or hulled grains are naturally more exposed to infestation, and the softer varieties suffer far more injury than do the harder, flinty sorts.

In times when grain was kept long in store, and long voyages were necessary in its transportation, losses through the depredations of insects were much heavier than at present, these pests being exceedingly prolific and increasing enormously under such conditions. Heat and dampness, the latter inducing a condition of the grain termed "heating," also favor the undue increase of insect life, and the insects, when present in large numbers, cause, in some unexplained manner, a very perceptible rise in temperature to the infested mass. It is unnecessary to add that dampness and "heating" alone do not of themselves engender "weevil," every individual insect owing its existence to an egg deposited in the grain by the parent insect.

THE GRAIN WEEVILS.

All the various species of insects that attack stored grain are indiscriminately called weevils, or simply "weevil," but the only true grain weevils are the granary weevil and rice weevil.

These two insects resemble each other in structure as well as in habit. They are small, flattened, brown snout-beetles of the family Calandridæ. Neither is more than a sixth of an inch in length, but their rate of development is so rapid that they do an almost incalculable amount of injury in a short period of time. Their heads are prolonged into a long snout or proboscis, at the end of which are the mandibles; their antennæ are elbowed and are attached to the proboscis.

THE GRANARY WEEVIL (*Calandra granaria* Linn.).

The granary weevil has been known as an enemy to stored grain since the earliest times. Having become domesticated ages ago, it has long since lost the use of its wings and is strictly an indoor species.

The mature weevil measures from an eighth to a sixth of an inch, is uniform shining chestnut brown in color, and has the thorax sparsely and longitudinally punctured, as indicated, much enlarged, at fig. 1, *a*.

The larva is legless, considerably shorter than the adult, white in color, very robust, fleshy, and of the form shown in the illustration (*b*). The pupa, illustrated at *c*, is also white, clear, and transparent, exhibiting the general characters of the future beetle.

The female punctures the grain with her snout and then inserts an egg, from which is hatched a larva that devours the mealy interior and

undergoes its transformations within the hull. In wheat and other small cereals a single larva inhabits a grain, but a kernel of maize furnishes food for several individuals.

The time required for the completion of the life cycle varies with the season and climate, and the number of generations annually produced is consequently dependent upon temperature. The midsummer period from egg to adult is about six weeks, and there may be, under favoring conditions, four or five broods in this latitude and six or even more in the South.

This species is injurious in wheat, maize, barley, and other grains and attacks also the chick-pea (*Cicer arictinum*), a food product of the Tropics. Unlike the moths which attack grain, the adult weevils feed also upon the kernels, gnawing into them for food and for shelter, and, being quite long-lived, probably do even more damage than their larvæ. This species is very prolific, egg-laying continuing over an extended period. It has been

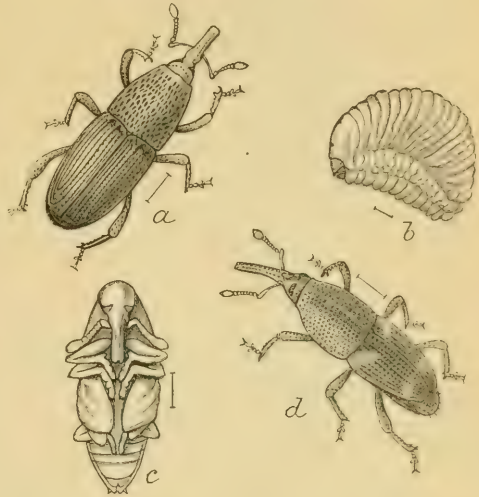


FIG. 1.—*Calandra granaria*: a, beetle; b, larva; c pupa; d, *C. oryza*, beetle—all enlarged (author's illustration).

estimated that one pair will, in the course of a year, produce 6,000 descendants, and it will be seen that the progeny of a single pair are capable in a short time of causing considerable damage.

THE RICE WEEVIL (*Calandra oryza* Linn.).

A very similar insect to the preceding is the rice weevil, which derives both its popular and Latin name from rice (*oryza*), in which it was originally discovered. It is conceded to have originated in India, whence it has been diffused by commerce until it is now established in most of the grain-growing countries of the world. It is a serious pest in the Southern States, where it is commonly, though erroneously, called "black weevil," but farther north is of less importance. It occurs, however, in every State and Territory in the Union, and occasionally invades Canada and Alaska.

This species resembles the granary weevil in size and general appearance, but differs in being dull brown in color, in having the thorax densely pitted with round punctures, and the elytra, or wing cases, ornamented with four more or less distinct red spots, arranged as in the illustration (fig. 1, d). Unlike the preceding species it has well-developed and serviceable wings. The larvæ and pupæ are also similar

to those of the granary weevil, and in habits and life history these two species do not materially differ, except in that the rice weevil may often be found in the field remote from the granary, and in the extreme South and in the Tropics lays its eggs in standing grain.

The rice weevil feeds upon the grain of rice, wheat, particularly the soft varieties, maize, barley, rye, hulled oats, buckwheat, chick-peas, and the cultivated varieties of sorghum known as Kafir, or Jerusalem corn, etc., and the adult beetles, when abundant in storehouses and groceries, invade boxes of crackers, cakes, and other breadstuffs, barrels of flour and bags of meal.

THE GRAIN MOTHS.

THE ANGOUMOIS GRAIN MOTH (*Sitotroga cerealella* OL.).

This moth received its name from the province of Angoumois, France, where it is known to have been injurious since the year 1736. In this country, where it is familiarly but incorrectly called "fly weevil," it is

said to have been recognized as early as 1728. From the seat of its supposed introduction, in North Carolina and Virginia, this moth has spread to neighboring States in the South, where it does incalculable damage, and to the southern portions of the Northern States, where it is less injurious. Although not so widely distributed as the true

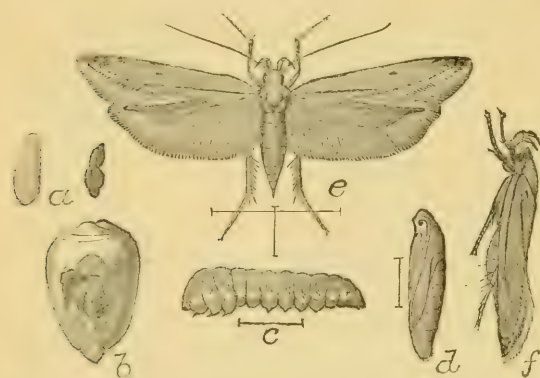


FIG. 2.—*Sitotroga cerealella*: a, eggs; b, larva at work; c, larva, side view; d, pupa; e, moth; f, same, side view (original).

grain weevils, it is rapidly increasing its range, and as it attacks grain in the field, even as far north as central Pennsylvania, as well as in the bin, is even a more serious pest in the localities in which it has become established than the weevils. It infests all the cereals, as well as buckwheat and the chick-pea, product of the Tropics. It has been estimated that in six months grain infested by this moth loses 40 per cent in weight and 75 per cent of farinaceous matter.

The adult insect resembles somewhat a clothes moth, for which indeed it is often mistaken. It is light grayish brown in color, more or less lined and spotted with black, and measures across the expanded fore-wings about half an inch (see fig. 2). The hind-wings are bordered with a long, delicate fringe.

The moth deposits its eggs in standing grain and in the bin, singly and in clusters of from 20 to 30. The eggs, shown, much enlarged, in the illustration, are white when first laid, but soon turn red and hatch

in from four to seven or more days, when the minute larvæ or caterpillars burrow into the kernels and feed on the starchy interior. A single larva inhabits a grain of the smaller cereals, but maize affords sustenance for two or more individuals. A kernel of corn opened to show the larva at work is reproduced at fig. 2, *b*, and an ear of infested pop-corn is shown at fig. 3. In three weeks or more, according to season, the caterpillar attains maturity, when it spins within the kernel a thin, silken cocoon and transforms to a pupa or chrysalis, the moth emerging a few days later, the entire period from egg to adult embracing in summer time about five weeks and in colder weather considerably longer. After copulation, the moth deposits eggs for another brood, and thus several generations are produced in the course of a year. The older writers state that the species is double-brooded, but as it breeds continuously in harvested grain, there is now, as in the case of most indoor insects, an irregular development, influenced by temperature. In the latitude of the District of Columbia, in an outdoor exposure, such as is afforded by an old-fashioned cornerrib, there are probably not more than four broods, the insect hibernating as larva in the grain, but in a heated atmosphere we have the possibility of five or six generations annually. In the warmer climate of the South, where the insect can breed uninterruptedly throughout the winter, it has been estimated that as many as eight generations may be produced.

THE WOLF MOTH (*Tinea granella* Linn.).

The wolf, or little grain moth, does considerable injury to stored cereals in Europe, but as it is not particularly destructive in America, requires only passing mention. This species is of about the size of the Angoumois moth, creamy white in color, thickly mottled with brown. Like the latter, it is known to oviposit in grain in the field. It infests cereals of all sorts, and a single caterpillar is capable of great damage, as it has a habit of passing from one grain to another, spinning them together with its webs as it goes, until twenty or thirty grains are spoiled. When full grown the caterpillars crawl all about the infested mass, leaving their webs everywhere, thus injuring even more than they consume.

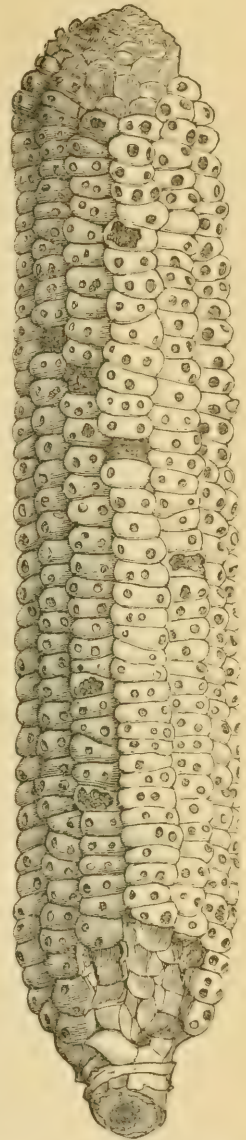


FIG. 3 — Ear of pop-corn showing work of Angoumois grain moth (From Riley in Ann. Rept. Dept. Agr., 1884).

FLOUR AND MEAL MOTHS.

Four or five species of moths, in addition to the one just mentioned, are injurious to grain in store, but are more prevalent in mill products, and are troublesome as well by their depredations in a variety of articles.

THE MEDITERRANEAN FLOUR MOTH (*Ephestia kuehniella* Zell.).

The most important of all mill insects is the Mediterranean flour moth. This scourge of the flour mill, as it is called, has attracted much attention of recent years and has been the subject of many articles and bulletins. Until the year 1877, when the moth was discovered in a flour mill in Germany, it was comparatively unknown. In later years it invaded Belgium and Holland, and in 1886 appeared in England. Three years later it made its appearance in destructive numbers in Canada. In 1892 it was reported injurious in mills in California, and in 1895 in New York and Pennsylvania.

That the Mediterranean flour moth has become so formidable in recent years is due to the higher and more equable temperature maintained in modern mills, a condition highly favorable to the development of the insect.

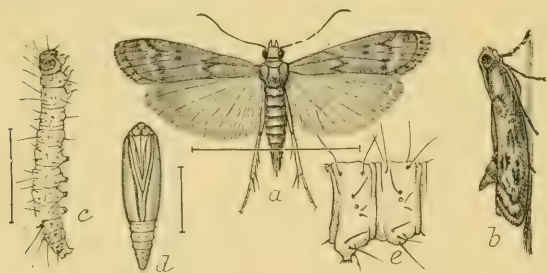


FIG. 4.—*Ephestia kuehniella*: a, moth; b, same from side, resting; c, larva; d, pupa—enlarged; e, abdominal joint of larva—more enlarged.



FIG. 5.—Larva, dorsal view (original).

Previous to the Canadian invasion this moth was generally believed to have reached Europe from America, but as a matter of fact the species had not been recognized here until 1889. Danysz has traced its occurrence in this country back as far as 1880. He mentions also an outbreak in Constantinople in 1872 and presents evidence that it was probably known in Europe as early as 1840. The species is recorded from specimens in collections from North Carolina, Alabama, New Mexico, Colorado, Mexico, and Chile. Of the last-mentioned localities it seems to be known as injurious only in Mexico. There is evidence to show that it probably occurs also in Australia.

The adult moth has a wing expanse of a little less than an inch; the fore-wings are pale leaden gray, with transverse black markings of the pattern shown in the accompanying illustration (fig. 4, a); the hind-wings are dirty whitish, semitransparent, and with a darker border. The caterpillar, illustrated at fig. 4 c, c, and at fig. 5, is whitish and hairy. The chrysalis, shown at fig. 4 d, is reddish brown.

The caterpillars form cylindrical silken tubes in which they feed, and it is in great part their habit of web spinning that renders them so injurious where they obtain a foothold. Upon attaining full growth the caterpillar leaves its original silken domicile and forms a new web, which becomes a cocoon, in which to undergo its transformations to pupa and to imago. It is while searching for a proper place for transformation that the insect is most troublesome. The infested flour becomes felted together and lumpy, the machinery becomes clogged, necessitating frequent and prolonged stoppage, and resulting in a short time in the loss of thousands of dollars, in large establishments.

Although the larva prefers flour or meal, it will attack grain when the former are not available, and it flourishes also on bran, prepared cereal foods, including buckwheat grits and crackers. In California it lives in the nests of a wild bumble-bee and in the hives of the honey bee.

In Europe it has been observed that the insect is able to complete its life cycle in two months, but from experiments recently conducted at Washington it has been demonstrated that under the most favorable conditions—i. e., in the warmest weather—the life cycle may be passed in thirty-eight days. In its outdoor life there are probably not more than two or three broods in the year, but in well-heated mills or other buildings six or more generations may be produced.

This insect is rapidly becoming distributed throughout the civilized world, but as yet its range is limited. From the reports of its alarming destructiveness in Great Britain and Canada, it would readily be inferred that this moth is peculiarly qualified for an indoor existence in much colder climates than most other grain insects.

When a mill is found to be infested, the entire building should be fumigated, and in case a whole district becomes overrun the greatest care must be observed not to spread the infestation. Uninfested mills should be tightly closed at night, and every bushel of grain, every bag or sack brought into the mill, subjected to a quarantine process, by being disinfected either by heat or bisulphide of carbon.

THE INDIAN-MEAL MOTH (*Plodia interpunctella* Hbn.).

An insect known as the Indian-meal moth may often be seen flying about in mills and stores, where it feeds on edibles of almost every kind—meal, flour, bran, grain of all sorts, dried fruits, seeds and nuts, condiments, roots, and herbs.

The adult moth is shown in the accompanying illustration (fig. 6, *a*). It measures across the expanded wings between a half and three-fourths of an inch. The inner third of the fore-wings is dirty whitish gray, and the outer two-thirds are reddish brown, with a dull coppery luster. The caterpillar is shown at *c*, *c*, *d*, and *f* and the chrysalis at *b*.

The caterpillars spin large quantities of silken threads with which they fasten together seeds, grain, or particles of whatever material they happen to infest, and it has recently been observed that they have a

special fondness for the embryo of wheat and pass from grain to grain, devouring only the germ, and attaching them together as they go. As they also deposit large quantities of excrement which becomes attached

to the silk it will be seen that they injure both for seed and for food many times the amount of grain actually consumed.

Experiment shows that the insect is capable of passing through all its several stages, from egg to adult, in five weeks, which furnishes a possibility of

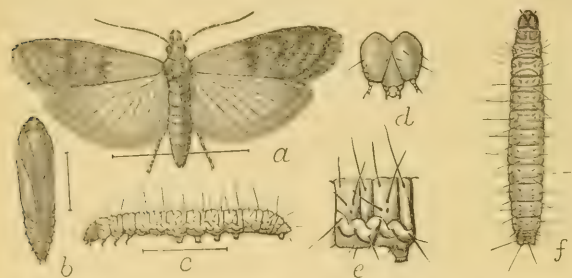


FIG. 6.—*Plodia interpunctella*: a, moth; b, chrysalis; c, caterpillar; f same dorsal view—somewhat enlarged; d, head, and e, first abdominal segment of caterpillar—more enlarged (author's illustration).

six or more generations in a well-heated atmosphere, although in a moderately cool granary or other storehouse four or five broods is probably the normal number per annum.

THE MEAL SNOOT-MOTH (*Pyralis farinalis* Linn.).

This meal moth often occurs where edible products are housed. It is slightly larger than the species previously mentioned, having a wing expanse of nearly an inch. The ground color is light brown, with reddish reflections; the thorax and the dark patches at its sides and near the tips of the fore-wings are darker brown. The wavy, transverse lines of the wings are whitish, and form the pattern indicated in the illustration (fig. 7, a). The caterpillar and chrysalis are figured, twice natural size, at b and c, respectively. In its habits it somewhat resembles the preceding species. The caterpillar constructs peculiar long tubes of silk and particles of the meal or other food upon which it lives. It infests cereals of all kinds and conditions, in the kernel or in the form of flour, meal, bran, or straw. It also attacks other seeds and dried plants, injures hay after the manner of the related clover-hay worm, and has been reported injurious to potatoes.



FIG. 7.—*Pyralis farinalis*: a, adult moth; b, larva; c, pupa in cocoon—twice natural size (author's illustration).

The life history of the meal snout-moth has not until recently been properly understood, the efforts to rear and observe it having always proved unsatisfactory. Certain European writers have expressed the belief that the species is biennial in development, but experiments

now being conducted go to prove at least four generations a year. The species has been carried through all its stages this spring in about eight weeks. It appears to require a certain amount of moisture, such as is present in "heated" grain or hay, for its full development.

No danger need be apprehended from injuries by this insect if material upon which it is likely to feed be kept in a clean, dry place. Almost without exception the cases of damage attributable to it have occurred in cellars, upon floors, in outhouses, or in places where refuse vegetable matter has accumulated.

THE FLOUR BEETLES.

Several little flattened beetles, of a shining brown color and similar appearance generally, so frequently occur in bags and barrels of flour as to have earned the popular title of "flour weevils." They live upon cereal and other seeds and various other stored products, but generally prefer flour and meal and patented articles of diet containing farinaceous matter.

Their eggs are often deposited in the flour in mills, and these and the larvæ they produce being minute and pale in color readily escape notice; but after the flour has been barreled or placed in bags and left unopened for any length of time the adult beetles make their appearance, and in due course the flour is ruined, for when the insects have time to propagate they soon convert the flour into a gray, useless mass. A part of the annoyance to purchaser, dealer, and manufacturer is due to the fact that the insects are highly offensive, a few specimens being sufficient to impart a disagreeable and persistent odor to the infested substance.

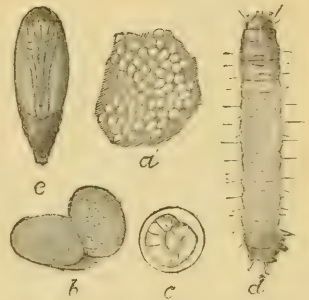


FIG. 8.—*Pyralis farinalis*: a, egg mass; b, eggs—more enlarged; c, egg showing embryo within; d, larva, dorsal view; e, pupa—all enlarged (author's illustration).

THE CONFUSED FLOUR BEETLE (*Tribolium confusum* Duv.).

The most important of the flour beetles is the one above mentioned. It is about the same size as the true grain weevils, is of nearly universal occurrence in grain of all kinds following the attacks of the latter species with which it is very often associated. Its principal damage, however, appears to be to flour and other patented articles of diet containing starchy matter; in fact, it is without doubt the insect most injurious to prepared cereal foods, if we except the Mediterranean flour moth, which fortunately is as yet confined to a limited territory.

Although known for many years in Europe as an enemy to stored cereals, seeds, and even as a pest in museums, it was not until the fall of 1893 that it was recognized in this country as a species distinct from others of its kind. In less than two years from the time of its first recognition here, this insect had been reported as injurious in nearly every

State and Territory. The divisional experience of a single year, 1894, shows that more complaints are made of injuries by this than of any other granivorous insect. As a mill pest it was the most troublesome species of 1895, and annually costs the millers of the United States thousands of dollars by its presence in manufactured products.

The mature beetle is scarcely a sixth of an inch long, elongate, and flattened, brown in color, and of the form indicated in the illustration (fig. 9, *a*). The head, with antenna, is shown, much enlarged

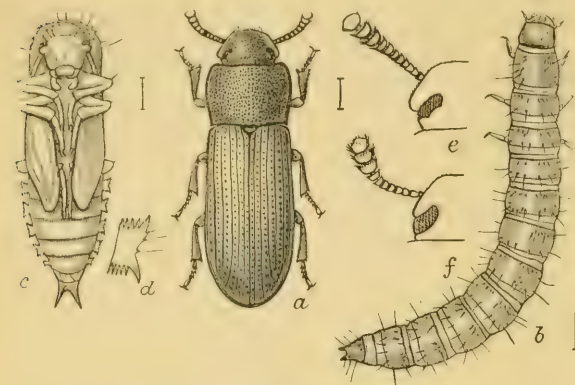


FIG. 9.—*Tribolium confusum*: *a*, beetle; *b*, larva; *c*, pupa—all enlarged; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle showing antenna; *f*, same of *T. ferrugineum*—all greatly enlarged (author's illustration).

ed, at *e*, and the general characters of the larva are illustrated at *b*, the pupa at *c* and *d*.

Among the many substances attacked by this insect may be mentioned, besides grain and its manufactured products, snuff, orris root, baking powder, rice chaff, red pepper, ginger, slippery elm, peas, beans, nuts, and seeds of various kinds, in all of which it has been found by the writer. It sometimes also invades cabinets of dried insects.

From experiment it has been learned that this species, in an exceptionally high temperature, is capable of undergoing its entire round of transformations in thirty-six days, but in spring and autumn weather it requires a much longer time. In well-heated buildings at this rate there are at least four broods a year.

OTHER FLOUR BEETLES.—

Other species of flour beetles are injurious in the same manner, but as yet are much less widely distributed in this country. Prominent among these in the Southern States are the following:

THE RUST-RED FLOUR BEETLE (*Tribolium ferrugineum* Fab.).

This resembles the preceding species in color, form, and size, but may be distinguished by the form of the head, which is not expanded

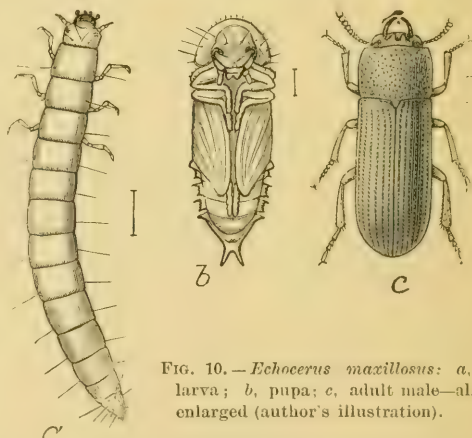


FIG. 10.—*Echocerus maxillosus*: *a*, larva; *b*, pupa; *c*, adult male—all enlarged (author's illustration).

beyond the eyes at the sides and by the antennae, which terminate in a distinct three-jointed club (see fig. 9, *f*). In its habits and life history it also closely resembles the preceding, but it is apparently somewhat restricted to the Southern States, although occasionally found in the North. It is often reported in flour, meal, and grain, and is sometimes shipped north in consignments of rice.

THE SLENDER-HORNED FLOUR BEETLE (*Echocerus maxillosus* Fab.).

The above-named insect should be mentioned here. It also feeds on flour and meal and is of frequent occurrence in the South and has been found as far north as the District of Columbia and southern Ohio in Indian corn, which appears to be its preferred food. The beetle resembles the two preceding species, but is lighter in color and a little smaller, measuring a trifle over an eighth of an inch in length. On the head, between the eyes, are two pointed tubercles, and the mandibles in the male are armed with a pair of slender, incurved horns. The insect in its several stages is illustrated at fig. 10.

THE BROAD-HORNED FLOUR BEETLE (*Echocerus cornutus* Fab.).

A flour beetle that sometimes finds its way into stores is the one above mentioned. It also closely resembles preceding species, but may be distinguished from them by the broad, conspicuous mandibular horns in the male (see fig. 11). It has been found in ground cereals of various sorts, including flour, meal, "germea," rolled barley, bread, army biscuit, maize, wheat, and rice. In southern California it occurs even under bark, showing complete acclimatization. Its distribution in the United States is at present limited, but it is frequently met with in seaport towns, especially on the Pacific Coast, and is on the increase elsewhere. In some parts of Europe it is a veritable pest in bakeries by getting into the flour and into the masses of fermenting dough that accumulate upon the molds used in baking bread.

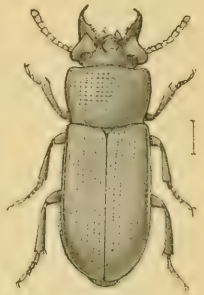


FIG. 11.—*Echocerus cornutus*, male—enlarged (author's illustration).

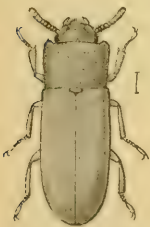


FIG. 12.—*Putorius ratzeburgi*—much enlarged (original).

THE SMALL-EYED FLOUR BEETLE (*Putorius ratzeburgi* Wissm.).

The smallest of the flour beetles known to injure cereals in this country is the one figured herewith. It looks not unlike preceding species, but, by comparison of specimens with a good lens, the differences are apparent. Although seldom recognized it is already known to be more widely distributed in the United States than at least two of the preceding forms. The first report of its occurrence in this country was in 1882, when it was the cause of much annoyance in a mill near Detroit, Mich. In the District of Columbia it ranks second among flour beetles in abundance and injuriousness in feed stores, bakeries, and other places where cereal products are kept

in store. In its habits it does not differ appreciably from other flour beetles, being much more injurious to ground products than to the seed of cereals.

THE MEAL-WORMS.

Two species of beetles and their larvæ, the latter known under the familiar name of "meal-worms," attract attention by reason of their large size and somewhat serpent-like appearance when present in open flour barrels, feed boxes, and bags of bran or meal. They are among the many species that develop in refuse grain dust and mill products

that are carelessly permitted to accumulate in the dark corners and out-of-the-way places in flouring mills, bakeries, feed stores, pigeon lofts, and stables. The two species are about equally common and do not differ materially in their habits, and, although abundant enough wherever grain is stored, do little or no damage to seed stock, being found mostly in corn meal and other ground products. They are also sometimes injurious to

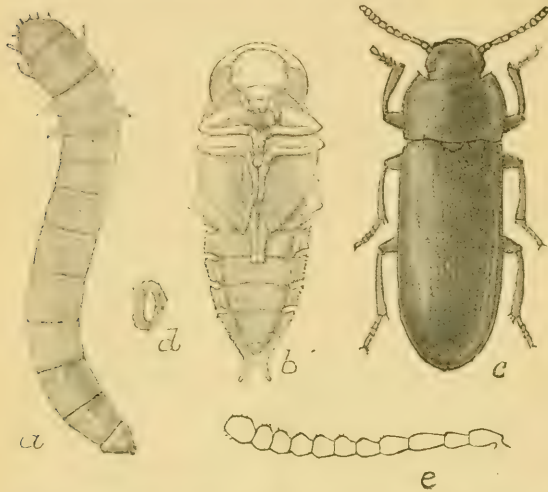


FIG. 13.—*Tenebrio molitor*: a, larva; b, pupa; c, female beetle; d, egg, with surrounding case; e, antenna—*a*, *b*, *c*, *d*, about twice natural size, *e*, more enlarged (original).

ship biscuit. As with some of the other storehouse insects, the *Tenebrios* are not an unmixed evil, for they have a commercial value to the bird fancier, being used as food for nightingales, mocking birds, and other feathered pets.

THE YELLOW MEAL-WORM (*Tenebrio molitor* Linn.).

The above-mentioned species is the meal-worm most often referred to in scientific literature, and as it is in the larval stage that it is best known, the name yellow meal-worm has been suggested to distinguish it from the other species, which is much darker in color. The larva (see fig. 13, *a*) is cylindrical, long, and slender, attaining a length of upward of an inch, and being about eight times as long as broad. It is waxen in appearance, resembling a wireworm. In color it is yellow, shading to darker ochreous toward each end and near the articulation of each joint. The anal extremity terminates in two minute spines. The pupa (*b*) is white, and the adult insect, as will be seen by reference to the illustration, resembles on a large scale one of the flour

beetles. It is considerably over half an inch long, somewhat flattened, shining, and nearly black. An enlarged antenna is shown at *e*.

The eggs, one of which is shown at *d*, with its covering of meal, are white, bean-shaped, and about a twentieth of an inch long, and are deposited by the parent beetle in the meal or other substance which is to serve as the food of the future larva.

The beetles begin to appear in the latitude of Washington in April and May, occurring most abundantly in the latter month and in June. In about two weeks from the time the eggs are laid the infant meal-worm, which is at first clear white in color and with prominent antennae and legs, makes its appearance, and as it feeds voraciously its growth is rapid. In three months it attains approximate growth, and from then till the following spring undergoes little change. It then becomes a pupa, and in this state remains about a fortnight. It will therefore be seen that this species is annual in development, a single brood only appearing each year. The beetles are nocturnal, and, being moderately strong flyers, are often attracted to lights. They have the pungent odor characteristic of the flour beetles and related species.

THE DARK MEAL-WORM (*Tenebrio obscurus* Linn.).

The darker of the two meal-worm larvæ has been called by writers the American meal-worm, an obvious misnomer, as this species, like the preceding, is believed by scientists to have come originally from temperate Europe or Siberia and is, like other species most commonly found in the storehouse, an introduced cosmopolite.

The mature insect, illustrated at fig. 14, is very similar to the parent of the yellow meal-worm, being of nearly the same dimensions but distinguishable by its color, which is dull piceous black. There are other points of difference, notably in the antennæ, the third joint in the present species being perceptibly longer than in *molitor*. The larva also resembles that of the preceding, differing chiefly in its much darker brownish markings. The pupa, however, is of the same whitish color.

The beetles, in the writer's experience, begin to appear considerably earlier than do those of the yellow meal-worm. Hence, at Washington they may be found as early as the latter part of February, remaining till the first of July, occurring most abundantly in April and May.

THE GRAIN BEETLES.

Several species of clavicorn beetles of the family Cucujidae occur in granaries, mills, and warehouses in the same situations as species previously treated. One of these is practically confined to the storehouse, usually following in the wake of other grain insects. The other two are



FIG. 14—*Tenebrio obscurus*: male—somewhat enlarged (original).

more often found in the open, but are capable of damage to stored foods if once they take up their habitation where these materials are kept.

THE SAW-TOOTHED GRAIN BEETLE (*Silvanus surinamensis* Linn.).

This little beetle is widely distributed over the entire globe, and of common occurrence in granaries and almost everywhere where edibles are stored. It is nearly omnivorous, infesting grain, flour, meal, dried fruits and seeds of all sorts, breadstuffs, and other comestibles, and though usually following the attacks of other insects is often reported as doing considerable damage.

The adult is very small, only about one-tenth of an inch long, slender, much flattened, and of a dark, chocolate-brown color. The antennae are clavate, or club-shaped, and the thorax has two shallow longitudinal grooves on the upper surface and bears six saw-like teeth on each side, as shown at fig. 15, *a*.

The larva is nearly white, and, as will be noticed by reference to the illustration (*c*), has six legs and an abdominal proleg. It is exceedingly active, and does not pass its life wholly within a single seed, but runs about nibbling here and there. After attaining its growth the larva attaches itself to some convenient surface and constructs a covering by joining together small grains or fragments of infested material by means of an adhesive substance which it secretes, and within this case the pupa (*b*) and afterwards the adult states are assumed.

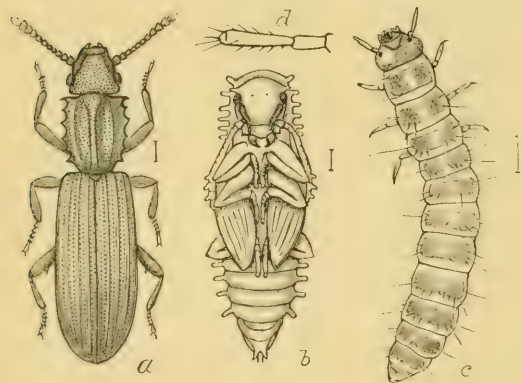


FIG. 15.—*Silvanus surinamensis*: *a*, adult beetle; *b* pupa; *c*, larva—all enlarged; *d*, antenna of larva—still more enlarged (author's illustration).

It is estimated that there are usually four, and that there may be as many as six generations of this insect annually in the latitude of the District of Columbia. During the warmest summer months the life cycle requires but twenty-four days; in early spring, from six to ten weeks. At Washington the species winters over, in the adult state, even in a well-warmed indoor atmosphere.

The mature beetles will feed upon sugar, and have been reported in starch, tobacco, and dried meats, but it is doubtful if the insect will breed in such substances. The beetles or their larvæ have a bad habit of perforating the paper bags in which flour and other comestibles are kept. When present in boxes of fruit there may be no visible evidence of their presence until the bottom is reached, but here they will be found in great numbers and when disturbed scamper off in great haste. This insect is almost invariably present wherever the Indian-meal

moth is found and the list of the food products that have been mentioned as subject to this moth's attack will answer about equally well for the beetle.

THE RED OR SQUARE-NECKED GRAIN BEETLE (*Cathartus gemellatus* Duv.).

An injurious enemy of Southern grain is the red or square necked grain beetle which is illustrated at fig. 16. It is of about the same length as the preceding species, to which it is nearly related and somewhat resembles, but the head and thorax are nearly as broad as the abdomen; the thorax is nearly square, not serrated on the sides, and the color is shining reddish-brown. In its earlier stages it also resembles the saw-toothed species.

It breeds in corn in the field as well as in cotton bolls and overripe or dried fruits, and continues breeding in harvested grain. It has been said that corn injured by this species has little chance of germinating, as the germ is nearly always first destroyed, and that this fact may, in some degree, account for the numerous failures of seed corn to grow, of which Southern planters so often complain. It is essentially an outdoor species, but when conditions favor its increase may become a serious pest in the granary, as it is capable of breeding from egg to adult in the short period of three weeks.



FIG. 16.—*Cathartus gemellatus* (original)

THE FOREIGN GRAIN BEETLE (*Cathartus advena* Waltl.).

The third grain beetle that will be considered is congeneric with the last. In life it is of a similar reddish color, but may be distinguished from the square-necked species by its smaller size. It is more robust, its thorax and elytra being proportionately wider (see fig. 17). Though an insect of wider distribution and diversity of food habits it has received scant attention at the hands of naturalists and its life economy has not been very fully studied.



FIG. 17.—*Cathartus advena*—much enlarged (original).

In the correspondence of the Division it has been reported injurious to stored wheat, to corn in stack, and to dried parsley, and has been found by the writer living in middlings, rice, dates, figs, table beans, cacao beans, and edible tubers. It has been also reported in abundance in flour, and during the year was taken in a feed store in this city.

In breeding experiments recently conducted by the writer it failed to develop in fresh grain or meal, but bred freely in corn meal which was moistened to produce mold. The beetles, particularly, fed freely on the molds, of which there were three or four species, and

it would appear that this is the normal habit of the insect. Hence, although this species may do a certain amount of injury to grain, little fear need be felt of any serious damage, provided the grain be stored in a clean, dry, well ventilated place.

THE CADELLE.

(*Tenebroides mauritanicus* Linn.).

The cadelle stands in a class by itself. It is almost as widely distributed as any of the preceding species, and did it not differ from all of them (except the meal-worms), in being annual in development as well as in being partially predaceous, might rival them in point of injuriousness.

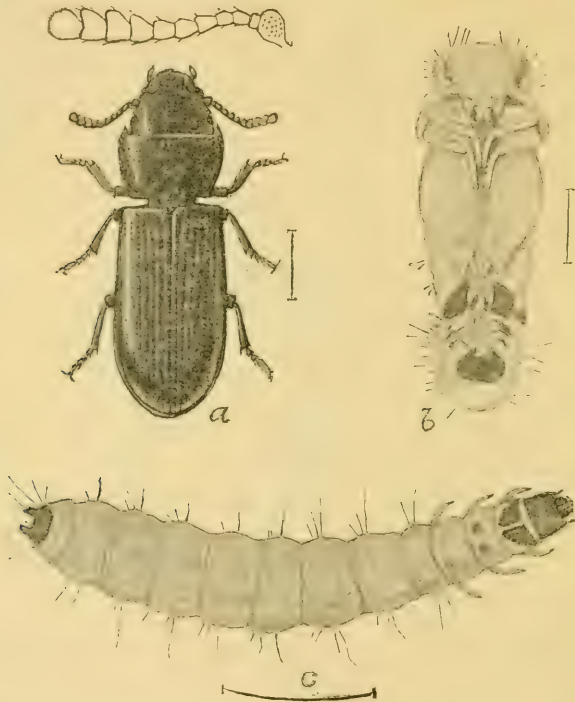


FIG. 18.—*Tenebroides mauritanicus*: *a*, adult beetle with greatly enlarged antenna above; *b*, pupa; *c*, larva—all enlarged (author's illustration).

The adult beetle, shown at fig. 18, *a*, is an elongate, oblong, depressed beetle, nearly black in color, and about one-third of an inch in length. The larva (*c*) is fleshy and slender, and measures when full grown nearly three-fourths of an inch. Its color is dull whitish, with a dark-brown head. The three thoracic segments are also marked with dark brown, and the tail terminates in two dark horny points. The pupa (shown at *b*) is also white.

The statements of some of the earlier writers that this species is granivorous has been discredited by later authors. It has been experimentally proven by the writer, however, that the insect lives both in

the larval and adult conditions upon grain; and furthermore, that were the insect more prolific it would become a source of much damage to seed stock from its habit of devouring the embryo, or germ, going from kernel to kernel and destroying for germinating purposes many more seeds than it consumes. Both larvæ and beetles serve a good purpose by attacking and destroying whatever other grain insects they happen to encounter.

PARASITIC AND OTHER NATURAL ENEMIES.

It might be supposed that insects which live a retired indoor existence would be comparatively free from parasitic and other enemies, but such is not the case.

It has been estimated of the granary weevil that one pair in the course of a year would produce 6,000 descendants. The moths are still more prolific, and as there are six or more broods of some species annually it will be seen that if all the eggs of one individual and her offspring develop there would be produced in one year a whole myriad of the insects, sufficient to destroy many tons of grain.

Fortunately, there are several natural checks to the undue increase of these insects. One of them is a diminutive mite which preys upon various species. Spiders that inhabit mills and granaries entrap the moths, and in the field they are preyed upon by nocturnal insects as well as by birds and bats.

The grain weevils and the Angoumois moth are often parasitized, two or three species of chalcis flies having been recognized as the enemies of each. The flour and meal moths each have several parasites, and most other granary insects are known to have either parasitic or predaceous enemies.

The good work that is sometimes done by parasites in limiting the multiplication of their grain-feeding hosts is exemplified in a case cited of the Mediterranean flour moth having been destroyed by a parasite when other means had failed to dislodge it in the warehouses which it had invaded.

METHODS OF CONTROL.

The measures to be employed in the control of insects affecting stored products are both preventive and insecticidal. As an insecticide nothing answers the purpose so well as the bisulphide of carbon, which is a nearly perfect remedy against all insects that infest the storehouse. The remedies that will be discussed in the present circular, while intended primarily for use against insects in stored grain, have an almost equal value against all forms of animal life that occur in products that are dried and kept in storage.

PREVENTIVE MEASURES.

A limited number of insects, like the Angoumois grain moth in the extreme South, enter the grain in the field, and certain precautions are therefore necessary to prevent their access to the granary. This is

accomplished, first, by harvesting as soon as the grain is ripe; second, by threshing as soon afterwards as possible.

In the process of threshing or cleaning much infested grain is blown out with the chaff and dust, and the moths and many adult weevils are killed by the agitation which the grain receives; but the immature forms of these insects, concealed in the kernels as eggs, larvæ, and pupæ, are apt to survive this treatment, and further measures are necessary for their destruction.

For this purpose a quarantine bin is desirable, to be as nearly airtight as possible, in which the newly threshed as well as the infested or suspected grain can be fumigated with bisulphide of carbon, according to the directions given on page 22.

Fresh grain should not be exposed to insect attack by being placed in bins with "weeviled" grain, or even housed under the same roof with such grain. If before storing in buildings that have been infested, the old grain be removed, the bins thoroughly cleaned, floors, walls, and ceilings brushed and scrubbed, the chances of infestation will be reduced to a minimum. If the storehouse has been badly infested, a fumigation with bisulphide is necessary.

The recent appearance of that most pernicious of mill pests, the Mediterranean flour moth, on the Pacific Coast and in certain locations in the East, has made indispensable the use of the bisulphide of carbon and the quarantine bin, and has brought to the fore a number of mechanical devices for its control. One of these is called a "steam sweeper," and certain mills in neighborhoods that are infested with this moth are already equipped with it. A steam pipe is run under the ceiling of each floor, and at intervals of about 25 feet a steam cock is placed, to which can be attached a hose for steaming the spouts and other portions of the infested machinery and all parts of the mill. The flour moth, as is well known, causes much trouble when in the larva or "worm" state by crawling into the spouts and elevator legs, where they spin their webs and clog the apertures. The liability of danger from this source may be obviated by the substitution of metal for the wooden apparatus generally in use, and already a metal spout has been patented and a metal elevator leg been devised for the express purpose of preventing this and other injurious insects from establishing themselves in these portions of the mill. Another device, called the "elevator brush," has been called into use to prevent the larvæ from choking up wooden spouts and elevator legs.

In times when the Angoumois grain moth was so injurious in France a number of machines were devised for the treatment of infested grain. Into these the grain is poured and revolved while exposed to heat or subjected to a violent agitation which kills the contained insects.

Cleanliness will accomplish much toward the prevention of injury from warehouse pests, the cause of a great proportion of injuries in granaries, mills, elevators, and other structures where grain and feed are stored being directly traceable to a disregard of neatness. Dust,

dirt, rubbish, and refuse material containing sweepings of grain, flour, and meal are too frequently permitted to accumulate and serve as breeding places for a multitude of injurious insects.

The floors of the storehouse should be frequently swept, and all material that has no commercial value burned.

A certain amount of attention has always been given to the construction of the storehouse with a view to the exclusion of insects, and, with the advent of the flour moth, our modern mills are being fitted with reference to its peculiar habits.

The ideal farmer's granary, from the standpoint of insect ravages, should be built at some distance from other buildings and the rooms constructed so as to be as near vermin proof as possible. The doors should fit tightly, and the windows covered with frames of wire gauze to prevent the passage of insects. The floor, walls, and ceilings should be smooth, so as not to afford any lurking places for the insects, and it would be well to have them oiled, painted, or whitewashed for further security. A coating of coal tar has been strongly recommended for the latter purpose. Such measures are not an absolute necessity in cold and temperate climates, but in the more heated atmosphere of our Southern States whatever possible should be done to lessen the chances of damage.

One of the latest things in the way of grain storage in connection with mills is the adoption of steel tanks for this purpose, for an account of which the reader is referred to the *American Miller* of May, 1896. It is claimed that the tanks are air-tight and fireproof and that in them "grain can be kept intact from any and all the destroying elements for an indefinite time."

The value of a cool place as a repository of grain has been known of old, and a building in which any artificial heat is employed is undesirable for grain storage. The "heating" and fermentation of grain, as is well known, is a productive source of "weevil," and this should be prevented by avoiding moisture and by ventilation.

The storage of grain in large bulk is to be commended, as the surface layers only are exposed to infestation. This practice is particularly valuable against the moths, which do not penetrate far beneath the surface. Frequent agitation of the grain is also destructive to the moths, as they are unable to extricate themselves from a large mass, and perish in the attempt. The rice and granary weevils, however, penetrate more deeply, and, although bulking is of value against them, it is not advisable to stir the grain, as it merely distributes them more thoroughly through the mass.

Many remedies have been proposed for use against stored grain insects, mostly of impractical or doubtful utility, and a long list of such substances, which are chiefly of a supposed repellant nature, could be given. The few of these which might be of value must be used in large quantity and in tight receptacles to be effective.

The most effective deterrent is naphthaline, which when used in tight

receptacles is an almost perfect preservative of seed stock and other products subject to insect attack. Its use is not, however, desirable with material that is to be used as food on account of its powerful and permanent odor. Salt, air-slaked lime, and powdered sulphur also serve the same purpose, but their use is also objectionable for different reasons.

INSECTICIDES AND OTHER DESTRUCTIVE AGENCIES.

Prior to the adoption of the bisulphide of carbon as a fumigant, heat was relied upon in the destruction of these insects. A temperature of from 125° to 140° F., continued for a few hours, is fatal to grain insects, and wheat can be subjected to a temperature of 150° for a short time without destroying its germinating power. Kiln-drying, at a still lower degree of heat, has been found effective.

A low temperature is equally destructive, and in colder climates these insects may be successfully dealt with by stirring or turning the infested grain, or by filling the buildings with steam and then throwing open the windows at night and exposing the insects to frost.

Steam, as has been said, is in successful use against the flour moth, and is employed in the same manner as bisulphide of carbon for the disinfection of bags and machinery in the quarantine box.

Sulphur, properly applied, may be used with benefit when for any reason the use of bisulphide is not advisable, and sulphur combined with steam is particularly destructive to insect life. Its use, however, is attended with certain disadvantages, necessitating the removal of all grain, as the former is apt to be injured for flour-making and the latter for bread-making purposes.

Benzine and naphtha or gasoline are of some value as fumigants for some materials, but do not produce entirely satisfactory results with grain, their vapors being insufficient for the destruction of the adolescent stages of species which breed wholly within the kernel, while each of these reagents possesses an offensive and more or less persistent odor. They are open, moreover, to the same objections as bisulphide of carbon, the vapor being about equally inflammable and more explosive.

THE BISULPHIDE OF CARBON TREATMENT.

The simplest, most effective, and inexpensive remedy for all insects that affect stored cereal and other products is the bisulphide of carbon, a colorless liquid with a strong, disagreeable odor, which, however, soon passes away. It vaporizes abundantly at ordinary temperatures, is highly inflammable, and is a powerful poison.

It may be applied directly to infested grain or seed without injury to its edible or germinative principles by spraying or pouring, but the most effective manner of its application in moderately tight bins or other receptacles consists in evaporating the liquid in shallow dishes or pans, or on bits of cloth or cotton waste distributed about on the surface of the infested material. The liquid rapidly volatilizes, and

being heavier than air descends and permeates the mass of grain, killing all insects and other vermin present.

The bisulphide is usually evaporated in vessels containing one-fourth or one-half of a pound each, and is applied in tight bins at the rate of a pound to a pound and a half to the ton of grain, and in more open bins a larger quantity is used. For smaller masses of grain or other material an ounce is evaporated to every 100 pounds of the infested matter. Bins may be rendered nearly air-tight by covering with cloths, blankets, or canvas.

Infested grain is generally subjected to the bisulphide treatment for twenty-four hours, but may be exposed much longer without harming it for milling purposes. If not exposed for more than thirty-six hours its germinating power will not be impaired. In open cribs and badly infested buildings it may sometimes be necessary to use a double quantity of the reagent and repeat treatment at intervals of about six weeks during the warmest weather.

Mr. H. E. Weed, entomologist of the Mississippi Experiment Station, claims that 1 pound to 100 bushels of grain is amply sufficient to destroy all insects, even in open cribs.

Mills and other buildings, when found to be infested throughout, may be thoroughly fumigated and rid of insects by a liberal use of the same chemical. A good time for this work is during daylight on a Saturday afternoon or early Sunday morning, closing the doors and windows as tightly as possible and observing the precaution of stationing a watchman without to prevent anyone from entering. It is best to begin in the lowest story and work upward, to escape the settling gas. The building should then be thoroughly aired and the grain stirred early Monday morning.

For the fumigation of a building or a reasonably close room it is customary to evaporate a pound of the bisulphide for every thousand feet of cubic space in comparatively empty rooms, and in such as do not admit of being tightly closed a considerably larger quantity of the chemical is sometimes necessary.

Certain precautions should always be observed. The vapor of bisulphide is deadly to all forms of animal life if inhaled in sufficient quantity, but there is no danger in inhaling a small amount. The vapor is inflammable, but with proper care that no fire of any kind, as, for example, a lighted cigar, be brought into the vicinity until the fumes have entirely passed away, no trouble will be experienced.

Bisulphide of carbon retails at from 20 to 30 cents a pound, but at wholesale, in 50-pound cans, may be obtained for 10 cents a pound. A grade known as "fuma bisulfide," for sale at the latter rate, is said to be more effective than the ordinary commercial article.

SUMMARY OF PRINCIPAL REMEDIES AND PREVENTIVES.

The bisulphide of carbon by reason of its intensive action is the best known remedy against all insects that affect stored products, and for this purpose is becoming indispensable, but in addition to its use various other measures, principally preventive, may be observed with profit for the preservation of grain against insect attack. The principal coordinate or additional measures may be summarized as follows:

(1) Prompt threshing to prevent the Angoumois grain moth, rice weevil, and some other species in the extreme South, from obtaining access to the granary.

(2) Inspection, quarantining, and disinfection of infested or suspected grain, bags, and machinery before permanent storage.

(3) Scrupulous cleanliness, including the prompt destruction of refuse material, which will accomplish much in lessening the chances of injury.

(4) Constructing or refitting the warehouse or mill, especially in warm latitudes, with a view to the exclusion of insects.

(5) Substitution of metal, for wooden, spouts, etc., and the use of other improved machinery in mills infested with the flour moth.

(6) Storage in large bulk, particularly valuable against grain moths.

(7) Storage in a cool, dry repository, well ventilated to prevent "heating."

(8) The use of naphthaline as a preservative of small samples in tight receptacles.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 45.

SOME INSECTS INJURIOUS TO STORED GRAIN.

BY

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SOME INSECTS INJURIOUS TO STORED GRAIN.

Stored grain is subject to injury by insects of several kinds, popularly termed "weevil." Upward of two score of species occur commonly in granaries, three living throughout their adolescent stages within the kernel of the grain. These three are the granary weevil, rice weevil, and Angoumois grain moth, the most injurious forms, both at home and abroad. The remaining species live on grain in the kernel, also when manufactured into flour and meal, and feed as well on various other edible products; hence, though of comparatively little importance as the authors of primary injury to the seed, they are very frequently the cause of serious damage to manufactured products and to grain that has suffered first from the attacks of the weevils or grain moth and has been kept for a length of time in store.

Nearly all of the grain-feeding species known in the United States have been introduced and are now cosmopolitan, having been distributed by commerce to all quarters of the earth, no insects being more easily carried from one land to another, since they breed continuously for years in the same grain and are unknowingly transported when in an immature state in the kernels. Most of our indoor insects are indigenous to the Tropics and do not thrive in the cold climate of our extreme northern States, but in the South they have become acclimated and there do their greatest damage.

NATURE AND EXTENT OF DAMAGE.

Aside from the loss in weight occasioned by the ravages of insects, grain infested by them is unfit for human consumption, and has been known to cause serious illness. Nor is such grain desirable for food for live stock or for seed, its use in the latter capacity being apt to be followed by a diminution in the yield of a crop.

Of the insect injury to stored grain it has been estimated of Texas alone that there is an annual loss of over a million dollars, and that nearly 50 per cent of the corn of that State is annually destroyed by weevils and rats. The loss from granary insects to the corn crop in Alabama in 1893 was estimated at \$1,671,382, or about 10 per cent.

There are seven other States subject to the same atmospheric and other influences as Alabama and producing in the aggregate a somewhat larger average yield of corn. Estimating the annual loss in the same proportions, we would have for these eight Southern States, viz: South

Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, and Arkansas, a total of nearly \$20,000,000. This is for corn alone, and does not take into consideration wheat and other grains or mill products.

In regard to the susceptibility of different grains to "weevil" attack, it may be said that unhusked rice, oats, and buckwheat are practically exempt, but the hull of barley offers less protection to the seed. Husked or hulled grains are naturally more exposed to infestation, and the softer varieties suffer far more injury than do the harder, flinty sorts.

In times when grain was kept long in store, and long voyages were necessary in its transportation, losses through the depredations of insects were much heavier than at present, these pests being exceedingly prolific and increasing enormously under such conditions. Heat and dampness, the latter inducing a condition of the grain termed "heating," also favor the undue increase of insect life, and the insects, when present in large numbers, cause, in some unexplained manner, a very perceptible rise in temperature to the infested mass. It is unnecessary to add that dampness and "heating" alone do not of themselves engender "weevil," every individual insect owing its existence to an egg deposited in the grain by the parent insect.

THE GRAIN WEEVILS.

All the various species of insects that attack stored grain are indiscriminately called weevils, or simply "weevil," but the only true grain weevils are the granary weevil and rice weevil.

These two insects resemble each other in structure as well as in habit. They are small, flattened, brown snout-beetles of the family Calandridæ. Neither is more than a sixth of an inch in length, but their rate of development is so rapid that they do an almost incalculable amount of injury in a short period of time. Their heads are prolonged into a long snout or proboscis, at the end of which are the mandibles; their antennæ are elbowed and are attached to the proboscis.

THE GRANARY WEEVIL (*Calandra granaria* Linn.).

The granary weevil has been known as an enemy to stored grain since the earliest times. Having become domesticated ages ago, it has long since lost the use of its wings and is strictly an indoor species.

The mature weevil measures from an eighth to a sixth of an inch, is uniform shining chestnut brown in color, and has the thorax sparsely and longitudinally punctured, as indicated, much enlarged, at fig. 1, *a*.

The larva is legless, considerably shorter than the adult, white in color, very robust, fleshy, and of the form shown in the illustration (*b*). The pupa, illustrated at *c*, is also white, clear, and transparent, exhibiting the general characters of the future beetle.

The female punctures the grain with her snout and then inserts an egg, from which is hatched a larva that devours the mealy interior and

undergoes its transformations within the hull. In wheat and other small cereals a single larva inhabits a grain, but a kernel of maize furnishes food for several individuals.

The time required for the completion of the life cycle varies with the season and climate, and the number of generations annually produced is consequently dependent upon temperature. The midsummer period from egg to adult is about six weeks, and there may be, under favoring conditions, four or five broods in this latitude and six or even more in the South.

This species is injurious in wheat, maize, barley, and other grains and attacks also the chick-pea (*Cicer arictinum*), a food product of the Tropics. Unlike the moths which attack grain, the adult weevils feed also upon the kernels, gnawing into them for food and for shelter, and, being quite long-lived, probably do even more damage than their larvæ. This species is very prolific, egg-laying continuing over an extended period. It has been estimated that one pair will, in the course of a year, produce 6,000 descendants, and it will be seen that the progeny of a single pair are capable in a short time of causing considerable damage.

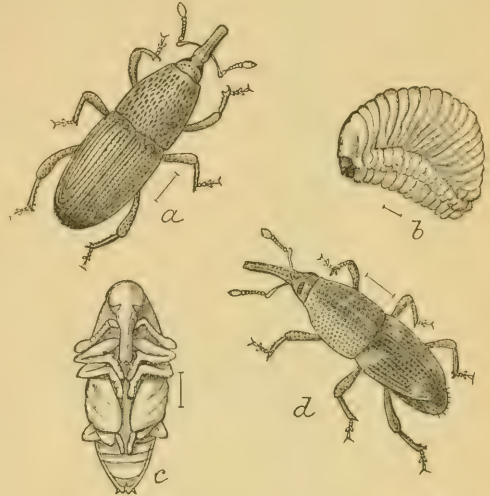


FIG. 1.—*Calandra granaria*: a, beetle; b, larva; c, pupa; d, *O. oryza*, beetle—all enlarged (author's illustration).

THE RICE WEEVIL (*Calandra oryza* Linn.).

A very similar insect to the preceding is the rice weevil, which derives both its popular and Latin name from rice (*oryza*), in which it was originally discovered. It is conceded to have originated in India, whence it has been diffused by commerce until it is now established in most of the grain-growing countries of the world. It is a serious pest in the Southern States, where it is commonly, though erroneously, called "black weevil," but farther north is of less importance. It occurs, however, in every State and Territory in the Union, and occasionally invades Canada and Alaska.

This species resembles the granary weevil in size and general appearance, but differs in being dull brown in color, in having the thorax densely pitted with round punctures, and the elytra, or wing cases, ornamented with four more or less distinct red spots, arranged as in the illustration (fig. 1, d). Unlike the preceding species it has well-developed and serviceable wings. The larvæ and pupæ are also similar

to those of the granary weevil, and in habits and life history these two species do not materially differ, except in that the rice weevil may often be found in the field remote from the granary, and in the extreme South and in the Tropics lays its eggs in standing grain.

The rice weevil feeds upon the grain of rice, wheat, particularly the soft varieties, maize, barley, rye, hulled oats, buckwheat, chick-peas, and the cultivated varieties of sorghum known as Kafir, or Jerusalem corn, etc., and the adult beetles, when abundant in storehouses and groceries, invade boxes of crackers, cakes, and other breadstuffs, barrels of flour and bags of meal.

THE GRAIN MOTHS.

THE ANGOUMOIS GRAIN MOTH (*Sitotroga cerealella* OL.).

This moth received its name from the province of Angoumois, France, where it is known to have been injurious since the year 1736. In this country, where it is familiarly but incorrectly called "fly weevil," it is

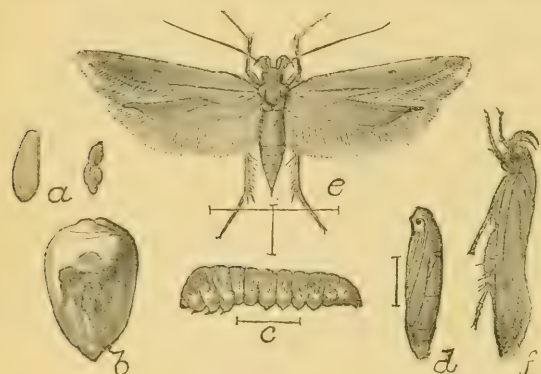


FIG. 2.—*Sitotroga cerealella*: a, eggs; b, larva at work; c, larva, side view; d, pupa; e, moth; f, same, side view (original).

said to have been recognized as early as 1728. From the seat of its supposed introduction, in North Carolina and Virginia, this moth has spread to neighboring States in the South, where it does incalculable damage, and to the southern portions of the Northern States, where it is less injurious. Although not so widely distributed as the true grain weevils, it is rapidly increasing its range, and as it attacks grain in the field, even as far north as central Pennsylvania, as well as in the bin, is even a more serious pest in the localities in which it has become established than the weevils. It infests all the cereals, as well as buckwheat and the chick-pea, product of the Tropics. It has been estimated that in six months grain infested by this moth loses 40 per cent in weight and 75 per cent of farinaceous matter.

The adult insect resembles somewhat a clothes moth, for which indeed it is often mistaken. It is light grayish brown in color, more or less lined and spotted with black, and measures across the expanded fore-wings about half an inch (see fig. 2). The hind-wings are bordered with a long, delicate fringe.

The moth deposits its eggs in standing grain and in the bin, singly and in clusters of from 20 to 30. The eggs, shown, much enlarged, in the illustration, are white when first laid, but soon turn red and hatch

in from four to seven or more days, when the minute larvæ or caterpillars burrow into the kernels and feed on the starchy interior. A single larva inhabits a grain of the smaller cereals, but maize affords sustenance for two or more individuals. A kernel of corn opened to show the larva at work is reproduced at fig. 2, *b*, and an ear of infested pop-corn is shown at fig. 3. In three weeks or more, according to season, the caterpillar attains maturity, when it spins within the kernel a thin, silken cocoon and transforms to a pupa or chrysalis, the moth emerging a few days later, the entire period from egg to adult embracing in summer time about five weeks and in colder weather considerably longer. After copulation, the moth deposits eggs for another brood, and thus several generations are produced in the course of a year. The older writers state that the species is double-brooded, but as it breeds continuously in harvested grain, there is now, as in the case of most indoor insects, an irregular development, influenced by temperature. In the latitude of the District of Columbia, in an outdoor exposure, such as is afforded by an old-fashioned cornerib, there are probably not more than four broods, the insect hibernating as larva in the grain, but in a heated atmosphere we have the possibility of five or six generations annually. In the warmer climate of the South, where the insect can breed uninterruptedly throughout the winter, it has been estimated that as many as eight generations may be produced.

THE WOLF MOTH (*Tinea granella* Linn.).

The wolf, or little grain moth, does considerable injury to stored cereals in Europe, but as it is not particularly destructive in America, requires only passing mention. This species is of about the size of the Angoumois moth, creamy white in color, thickly mottled with brown. Like the latter, it is known to oviposit in grain in the field. It infests cereals of all sorts, and a single caterpillar is capable of great damage, as it has a habit of passing from one grain to another, spinning them together with its webs as it goes, until twenty or thirty grains are spoiled. When full grown the caterpillars crawl all about the infested mass, leaving their webs everywhere, thus injuring even more than they consume.

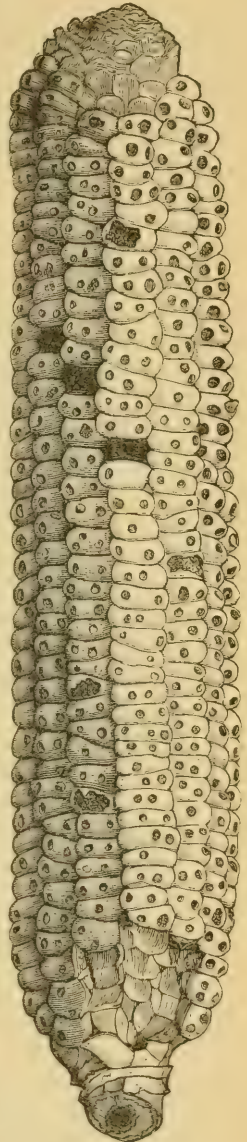


FIG. 3.—Ear of pop-corn showing work of Angoumois grain moth (from Riley in Ann. Rept. Dept. Agr., 1884).

FLOUR AND MEAL MOTHS.

Four or five species of moths, in addition to the one just mentioned, are injurious to grain in store, but are more prevalent in mill products, and are troublesome as well by their depredations in a variety of articles.

THE MEDITERRANEAN FLOUR MOTH (*Ephestia kuehniella* Zell.).

The most important of all mill insects is the Mediterranean flour moth. This scourge of the flour mill, as it is called, has attracted much attention of recent years and has been the subject of many articles and bulletins. Until the year 1877, when the moth was discovered in a flour mill in Germany, it was comparatively unknown. In later years it invaded Belgium and Holland, and in 1886 appeared in England. Three years later it made its appearance in destructive numbers in Canada. In 1892 it was reported injurious in mills in California, and in 1895 in New York and Pennsylvania.

That the Mediterranean flour moth has become so formidable in recent years is due to the higher and more equable temperature maintained in modern mills, a condition highly favorable to the development of the insect.

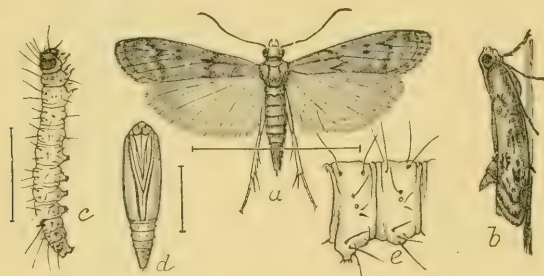


FIG. 4.—*Ephestia kuehniella*: a, moth; b, same from side, resting; c, larva; d, pupa—enlarged; e, abdominal joint of larva—more enlarged.



FIG. 5.—Larva, dorsal view (original).

Previous to the Canadian invasion this moth was generally believed to have reached Europe from America, but as a matter of fact the species had not been recognized here until 1889. Danysz has traced its occurrence in this country back as far as 1880. He mentions also an outbreak in Constantinople in 1872 and presents evidence that it was probably known in Europe as early as 1840. The species is recorded from specimens in collections from North Carolina, Alabama, New Mexico, Colorado, Mexico, and Chile. Of the last-mentioned localities it seems to be known as injurious only in Mexico. There is evidence to show that it probably occurs also in Australia.

The adult moth has a wing expanse of a little less than an inch; the fore-wings are pale leaden gray, with transverse black markings of the pattern shown in the accompanying illustration (fig. 4, a); the hind-wings are dirty whitish, semitransparent, and with a darker border. The caterpillar, illustrated at fig. 4 c, e, and at fig. 5, is whitish and hairy. The chrysalis, shown at fig. 4 d, is reddish brown.

The caterpillars form cylindrical silken tubes in which they feed, and it is in great part their habit of web spinning that renders them so injurious where they obtain a foothold. Upon attaining full growth the caterpillar leaves its original silken domicile and forms a new web, which becomes a cocoon, in which to undergo its transformations to pupa and to imago. It is while searching for a proper place for transformation that the insect is most troublesome. The infested flour becomes felted together and lumpy, the machinery becomes clogged, necessitating frequent and prolonged stoppage, and resulting in a short time in the loss of thousands of dollars, in large establishments.

Although the larva prefers flour or meal, it will attack grain when the former are not available, and it flourishes also on bran, prepared cereal foods, including buckwheat grits and crackers. In California it lives in the nests of a wild bumble-bee and in the hives of the honey bee.

In Europe it has been observed that the insect is able to complete its life cycle in two months, but from experiments recently conducted at Washington it has been demonstrated that under the most favorable conditions—i. e., in the warmest weather—the life cycle may be passed in thirty-eight days. In its outdoor life there are probably not more than two or three broods in the year, but in well-heated mills or other buildings six or more generations may be produced.

This insect is rapidly becoming distributed throughout the civilized world, but as yet its range is limited. From the reports of its alarming destructiveness in Great Britain and Canada, it would readily be inferred that this moth is peculiarly qualified for an indoor existence in much colder climates than most other grain insects.

When a mill is found to be infested, the entire building should be fumigated, and in case a whole district becomes overrun the greatest care must be observed not to spread the infestation. Uninfested mills should be tightly closed at night, and every bushel of grain, every bag or sack brought into the mill, subjected to a quarantine process, by being disinfected either by heat or bisulphide of carbon.

THE INDIAN-MEAL MOTH (*Plodia interpunctella* Hbn.).

An insect known as the Indian-meal moth may often be seen flying about in mills and stores, where it feeds on edibles of almost every kind—meal, flour, bran, grain of all sorts, dried fruits, seeds and nuts, condiments, roots, and herbs.

The adult moth is shown in the accompanying illustration (fig. 6, *a*). It measures across the expanded wings between a half and three-fourths of an inch. The inner third of the fore-wings is dirty whitish gray, and the outer two-thirds are reddish brown, with a dull coppery luster. The caterpillar is shown at *c*, *e*, *d*, and *f* and the chrysalis at *b*.

The caterpillars spin large quantities of silken threads with which they fasten together seeds, grain, or particles of whatever material they happen to infest, and it has recently been observed that they have a

special fondness for the embryo of wheat and pass from grain to grain, devouring only the germ, and attaching them together as they go. As they also deposit large quantities of excrement which becomes attached

to the silk it will be seen that they injure both for seed and for food many times the amount of grain actually consumed.

Experiment shows that the insect is capable of passing through all its several stages, from egg to adult, in five weeks, which furnishes a possibility of

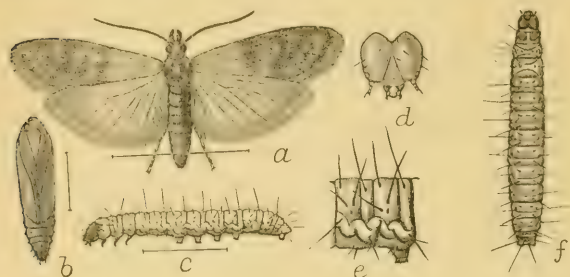


FIG. 6.—*Plodia interpunctella*: a, moth; b, chrysalis; c, caterpillar; f same dorsal view—somewhat enlarged; d, head, and e, first abdominal segment of caterpillar—more enlarged (author's illustration).

six or more generations in a well-heated atmosphere, although in a moderately cool granary or other storehouse four or five broods is probably the normal number per annum.

THE MEAL SNOOT-MOTH (*Pyralis farinalis* Linn.).

This meal moth often occurs where edible products are housed. It is slightly larger than the species previously mentioned, having a wing expanse of nearly an inch. The ground color is light brown, with reddish reflections; the thorax and the dark patches at its sides and near the tips of the fore-wings are darker brown. The wavy, transverse lines of the wings are whitish, and form the pattern indicated in the illustration (fig. 7, a). The caterpillar and chrysalis are figured, twice natural size, at b and c, respectively. In its habits it somewhat resembles the preceding species. The caterpillar constructs peculiar long tubes of silk and particles of the meal or other food upon which it lives. It infests cereals of all kinds and conditions, in the kernel or in the form of flour, meal, bran, or straw. It also attacks other seeds and dried plants, injures hay after the manner of the related clover-hay worm, and has been reported injurious to potatoes.



FIG. 7.—*Pyralis farinalis*: a, adult moth; b, larva; c, pupa in cocoon—twice natural size (author's illustration).

The life history of the meal snout-moth has not until recently been properly understood, the efforts to rear and observe it having always proved unsatisfactory. Certain European writers have expressed the belief that the species is biennial in development, but experiments

now being conducted go to prove at least four generations a year. The species has been carried through all its stages this spring in about eight weeks. It appears to require a certain amount of moisture, such as is present in "heated" grain or hay, for its full development.

No danger need be apprehended from injuries by this insect if material upon which it is likely to feed be kept in a clean, dry place. Almost without exception the cases of damage attributable to it have occurred in cellars, upon floors, in outhouses, or in places where refuse vegetable matter has accumulated.

THE FLOUR BEETLES.

Several little flattened beetles, of a shining brown color and similar appearance generally, so frequently occur in bags and barrels of flour as to have earned the popular title of "flour weevils." They live upon cereal and other seeds and various other stored products, but generally prefer flour and meal and patented articles of diet containing farinaceous matter.

Their eggs are often deposited in the flour in mills, and these and the larvæ they produce being minute and pale in color readily escape notice; but after the flour has been barreled or placed in bags and left unopened for any length of time the adult beetles make their appearance, and in due course the flour is ruined, for when the insects have time to propagate they soon convert the flour into a gray, useless mass. A part of the annoyance to purchaser, dealer, and manufacturer is due to the fact that the insects are highly offensive, a few specimens being sufficient to impart a disagreeable and persistent odor to the infested substance.

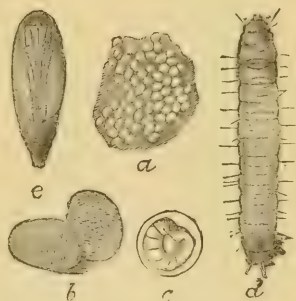


FIG. 8.—*Pyralis farinalis*: a, egg mass; b, eggs—more enlarged; c, egg showing embryo within; d, larva, dorsal view; e, pupa—all enlarged (author's illustration).

THE CONFUSED FLOUR BEETLE (*Tribolium confusum* Duv.).

The most important of the flour beetles is the one above mentioned. It is about the same size as the true grain weevils, is of nearly universal occurrence in grain of all kinds following the attacks of the latter species with which it is very often associated. Its principal damage, however, appears to be to flour and other patented articles of diet containing starchy matter; in fact, it is without doubt the insect most injurious to prepared cereal foods, if we except the Mediterranean flour moth, which fortunately is as yet confined to a limited territory.

Although known for many years in Europe as an enemy to stored cereals, seeds, and even as a pest in museums, it was not until the fall of 1893 that it was recognized in this country as a species distinct from others of its kind. In less than two years from the time of its first recognition here, this insect had been reported as injurious in nearly every

State and Territory. The divisional experience of a single year, 1894, shows that more complaints are made of injuries by this than of any other granivorous insect. As a mill pest it was the most troublesome

species of 1895, and annually costs the millers of the United States thousands of dollars by its presence in manufactured products.

The mature beetle is scarcely a sixth of an inch long, elongate, and flattened, brown in color, and of the form indicated in the illustration (fig. 9, *a*). The head, with antenna, is shown, much enlarged,

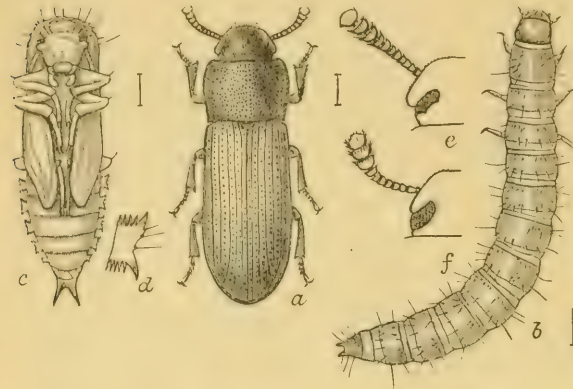


FIG. 9.—*Tribolium confusum*: *a*, beetle; *b*, larva; *c*, pupa—all enlarged; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle, showing antenna; *f*, same of *T. ferrugineum*—all greatly enlarged (author's illustration).

ed, at *e*, and the general characters of the larva are illustrated at *b*, the pupa at *c* and *d*.

Among the many substances attacked by this insect may be mentioned, besides grain and its manufactured products, snuff, orris root, baking powder, rice chaff, red pepper, ginger, slippery elm, peas, beans, nuts, and seeds of various kinds, in all of which it has been found by the writer. It sometimes also invades cabinets of dried insects.

From experiment it has been learned that this species, in an exceptionally high temperature, is capable of undergoing its entire round of transformations in thirty-six days, but in spring and autumn weather it requires a much longer time. In well-heated buildings at this rate there are at least four broods a year.

OTHER FLOUR BEETLES.—

Other species of flour beetles are injurious in the same manner, but as yet are much less widely distributed in this country. Prominent among these in the Southern States are the following:

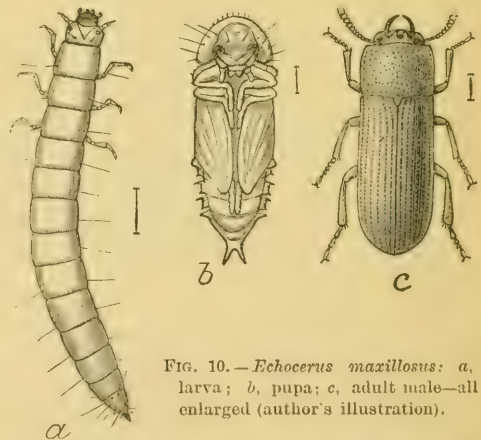


FIG. 10.—*Echocerus maxillosus*: *a*, larva; *b*, pupa; *c*, adult male—all enlarged (author's illustration).

THE RUST-RED FLOUR BEETLE (*Tribolium ferrugineum* Fab.).

This resembles the preceding species in color, form, and size, but may be distinguished by the form of the head, which is not expanded

beyond the eyes at the sides and by the antennæ, which terminate in a distinct three-jointed club (see fig. 9, *f'*). In its habits and life history it also closely resembles the preceding, but it is apparently somewhat restricted to the Southern States, although occasionally found in the North. It is often reported in flour, meal, and grain, and is sometimes shipped north in consignments of rice.

THE SLENDER-HORNED FLOUR BEETLE (*Echocerus maxillosus* Fab.).

The above-named insect should be mentioned here. It also feeds on flour and meal and is of frequent occurrence in the South and has been found as far north as the District of Columbia and southern Ohio in Indian corn, which appears to be its preferred food. The beetle resembles the two preceding species, but is lighter in color and a little smaller, measuring a trifle over an eighth of an inch in length. On the head, between the eyes, are two pointed tubercles, and the mandibles in the male are armed with a pair of slender, incurved horns. The insect in its several stages is illustrated at fig. 10.



THE BROAD-HORNED FLOUR BEETLE (*Echocerus cornutus* Fab.).

A flour beetle that sometimes finds its way into stores is the one above mentioned. It also closely resembles preceding species, but may be distinguished from them by the broad, conspicuous mandibular horns in the male (see fig. 11). It has been found in ground cereals of various sorts, including flour, meal, "germea," rolled barley, bread, army biscuit, maize, wheat, and rice. In southern California it occurs even under bark, showing complete acclimatization. Its distribution in the United States is at present limited, but it is frequently met with in seaport towns, especially on the Pacific Coast, and is on the increase elsewhere. In some parts of Europe it is a veritable pest in bakeries by getting into the flour and into the masses of fermenting dough that accumulate upon the molds used in baking bread.

Fig. 11.—*Echocerus cornutus*: male—enlarged (author's illustration).



Fig. 12.—*Palorus ratzeburgi*—much enlarged (original).

THE SMALL-EYED FLOUR BEETLE (*Palorus ratzeburgi* Wissm.).

The smallest of the flour beetles known to injure cereals in this country is the one figured herewith. It looks not unlike preceding species, but, by comparison of specimens with a good lens, the differences are apparent. Although seldom recognized it is already known to be more widely distributed in the United States than at least two of the preceding forms. The first report of its occurrence in this country was in 1882, when it was the cause of much annoyance in a mill near Detroit, Mich. In the District of Columbia it ranks second among flour beetles in abundance and injuriousness in feed stores, bakeries, and other places where cereal products are kept

in store. In its habits it does not differ appreciably from other flour beetles, being much more injurious to ground products than to the seed of cereals.

THE MEAL-WORMS.

Two species of beetles and their larva, the latter known under the familiar name of "meal-worms," attract attention by reason of their large size and somewhat serpent-like appearance when present in open flour barrels, feed boxes, and bags of bran or meal. They are among the many species that develop in refuse grain dust and mill products

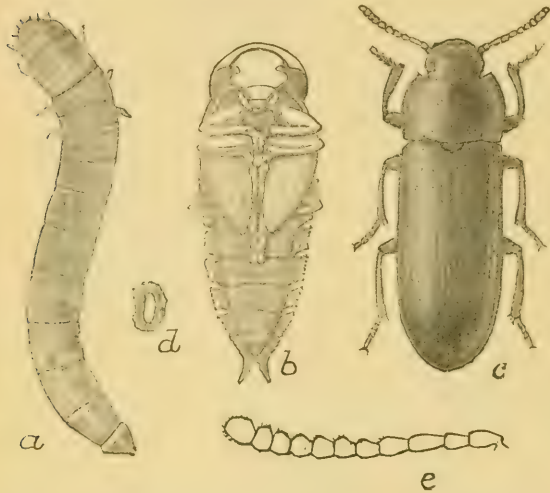


FIG. 13.—*Tenebrio molitor*: a, larva; b, pupa; c, female beetle; d, egg, with surrounding case; e antenna—*a*, *b*, *c*, *d*, about twice natural size; *e*, more enlarged (original).

that are carelessly permitted to accumulate in the dark corners and out-of-the-way places in flouring mills, bakeries, feed stores, pigeon lofts, and stables. The two species are about equally common and do not differ materially in their habits, and, although abundant enough wherever grain is stored, do little or no damage to seed stock, being found mostly in corn meal and other ground products. They are also sometimes injurious to ship biscuit. As with some of the other storehouse insects, the *Tenebrios* are not an unmixed evil, for they have a commercial value to the bird fancier, being used as food for nightingales, mocking birds, and other feathered pets.

THE YELLOW MEAL-WORM (*Tenebrio molitor* Linn.).

The above-mentioned species is the meal-worm most often referred to in scientific literature, and as it is in the larval stage that it is best known, the name yellow meal-worm has been suggested to distinguish it from the other species, which is much darker in color. The larva (see fig. 13, *a*) is cylindrical, long, and slender, attaining a length of upward of an inch, and being about eight times as long as broad. It is waxen in appearance, resembling a wireworm. In color it is yellow, shading to darker ochreous toward each end and near the articulation of each joint. The anal extremity terminates in two minute spines. The pupa (*b*) is white, and the adult insect, as will be seen by reference to the illustration, resembles on a large scale one of the flour

beetles. It is considerably over half an inch long, somewhat flattened, shining, and nearly black. An enlarged antenna is shown at *e*.

The eggs, one of which is shown at *d*, with its covering of meal, are white, bean-shaped, and about a twentieth of an inch long, and are deposited by the parent beetle in the meal or other substance which is to serve as the food of the future larva.

The beetles begin to appear in the latitude of Washington in April and May, occurring most abundantly in the latter month and in June. In about two weeks from the time the eggs are laid the infant meal-worm, which is at first clear white in color and with prominent antennæ and legs, makes its appearance, and as it feeds voraciously its growth is rapid. In three months it attains approximate growth, and from then till the following spring undergoes little change. It then becomes a pupa, and in this state remains about a fortnight. It will therefore be seen that this species is annual in development, a single brood only appearing each year. The beetles are nocturnal, and, being moderately strong flyers, are often attracted to lights. They have the pungent odor characteristic of the flour beetles and related species.

THE DARK MEAL-WORM (*Tenebrio obscurus* Linn.).

The darker of the two meal-worm larvæ has been called by writers the American meal-worm, an obvious misnomer, as this species, like the preceding, is believed by scientists to have come originally from temperate Europe or Siberia and is, like other species most commonly found in the storehouse, an introduced cosmopolite.

The mature insect, illustrated at fig. 14, is very similar to the parent of the yellow meal-worm, being of nearly the same dimensions but distinguishable by its color, which is dull piceous black. There are other points of difference, notably in the antennæ, the third joint in the present species being perceptibly longer than in *molitor*. The larva also resembles that of the preceding, differing chiefly in its much darker brownish markings. The pupa, however, is of the same whitish color.

The beetles, in the writer's experience, begin to appear considerably earlier than do those of the yellow meal-worm. Hence, at Washington they may be found as early as the latter part of February, remaining till the first of July, occurring most abundantly in April and May.

THE GRAIN BEETLES.

Several species of clavicorn beetles of the family Cucujidæ occur in granaries, mills, and warehouses in the same situations as species previously treated. One of these is practically confined to the storehouse, usually following in the wake of other grain insects. The other two are



FIG. 14.—*Tenebrio obscurus*: male—somewhat enlarged (original).

more often found in the open, but are capable of damage to stored foods if once they take up their habitation where these materials are kept.

THE SAW-TOOTHED GRAIN BEETLE (*Silvanus surinamensis* Linn.).

This little beetle is widely distributed over the entire globe, and of common occurrence in granaries and almost everywhere where edibles are stored. It is nearly omnivorous, infesting grain, flour, meal, dried fruits and seeds of all sorts, breadstuffs, and other comestibles, and though usually following the attacks of other insects is often reported as doing considerable damage.

The adult is very small, only about one-tenth of an inch long, slender, much flattened, and of a dark, chocolate-brown color. The antennae are clavate, or club-shaped, and the thorax has two shallow longitudinal grooves on the upper surface and bears six saw-like teeth on each side, as shown at fig. 15, *a*.

The larva is nearly white, and, as will be noticed by reference to the illustration (*c*), has six legs and an abdominal proleg. It is exceedingly active, and does not pass its life wholly within a single seed, but runs about nibbling here and there. After attaining its growth the larva attaches itself to some convenient surface and constructs a covering by joining together small grains or fragments of infested material by means of an adhesive substance which it secretes, and within this case the pupa (*b*) and afterwards the adult states are assumed.

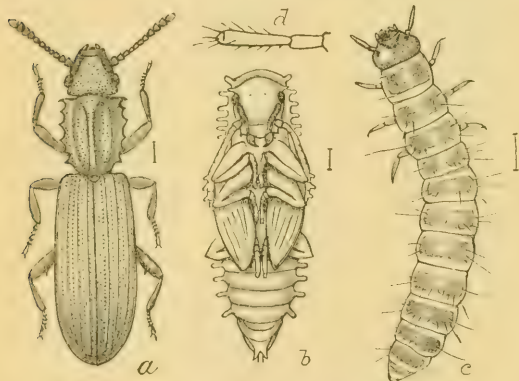


FIG. 15.—*Silvanus surinamensis*: *a*, adult beetle; *b* pupa; *c*, larva—all enlarged; *d*, antenna of larva—still more enlarged (author's illustration).

It is estimated that there are usually four, and that there may be as many as six generations of this insect annually in the latitude of the District of Columbia. During the warmest summer months the life cycle requires but twenty-four days; in early spring, from six to ten weeks. At Washington the species winters over, in the adult state, even in a well-warmed indoor atmosphere.

The mature beetles will feed upon sugar, and have been reported in starch, tobacco, and dried meats, but it is doubtful if the insect will breed in such substances. The beetles or their larvæ have a bad habit of perforating the paper bags in which flour and other comestibles are kept. When present in boxes of fruit there may be no visible evidence of their presence until the bottom is reached, but here they will be found in great numbers and when disturbed scamper off in great haste. This insect is almost invariably present wherever the Indian-meal

moth is found and the list of the food products that have been mentioned as subject to this moth's attack will answer about equally well for the beetle.

THE RED OR SQUARE-NECKED GRAIN BEETLE (*Cathartus gemellatus* Duv.).

An injurious enemy of Southern grain is the red or square necked grain beetle which is illustrated at fig. 16. It is of about the same length as the preceding species, to which it is nearly related and somewhat resembles, but the head and thorax are nearly as broad as the abdomen; the thorax is nearly square, not serrated on the sides, and the color is shining reddish-brown. In its earlier stages it also resembles the saw-toothed species.

It breeds in corn in the field as well as in cotton bolls and overripe or dried fruits, and continues breeding in harvested grain. It has been said that corn injured by this species has little chance of germinating, as the germ is nearly always first destroyed, and that this fact may, in some degree, account for the numerous failures of seed corn to grow, of which Southern planters so often complain. It is essentially an outdoor species, but when conditions favor its increase may become a serious pest in the granary, as it is capable of breeding from egg to adult in the short period of three weeks.

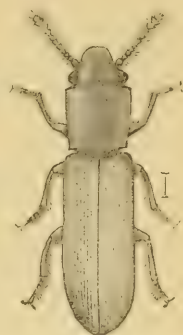


FIG. 16 — *Cathartus gemellatus* (original).

THE FOREIGN GRAIN BEETLE (*Cathartus advena* Waltl.).

The third grain beetle that will be considered is congeneric with the last. In life it is of a similar reddish color, but may be distinguished from the square-necked species by its smaller size. It is more robust, its thorax and elytra being proportionately wider (see fig. 17). Though an insect of wider distribution and diversity of food habits it has received scant attention at the hands of naturalists and its life economy has not been very fully studied.



FIG. 17.—*Cathartus advena*—much enlarged (original).

In the correspondence of the Division it has been reported injurious to stored wheat, to corn in stack, and to dried parsley, and has been found by the writer living in middlings, rice, dates, figs, table beans, cacao beans, and edible tubers. It has been also reported in abundance in flour, and during the year was taken in a feed store in this city.

In breeding experiments recently conducted by the writer it failed to develop in fresh grain or meal, but bred freely in corn meal which was moistened to produce mold. The beetles, particularly, fed freely on the molds, of which there were three or four species, and

it would appear that this is the normal habit of the insect. Hence, although this species may do a certain amount of injury to grain, little fear need be felt of any serious damage, provided the grain be stored in a clean, dry, well ventilated place.

THE CADELLE.

(*Tenebroides mauritanicus* Linn.).

The cadelle stands in a class by itself. It is almost as widely distributed as any of the preceding species, and did it not differ from all of them (except the meal-worms), in being annual in development as well as in being partially predaceous, might rival them in point of injuriousness.

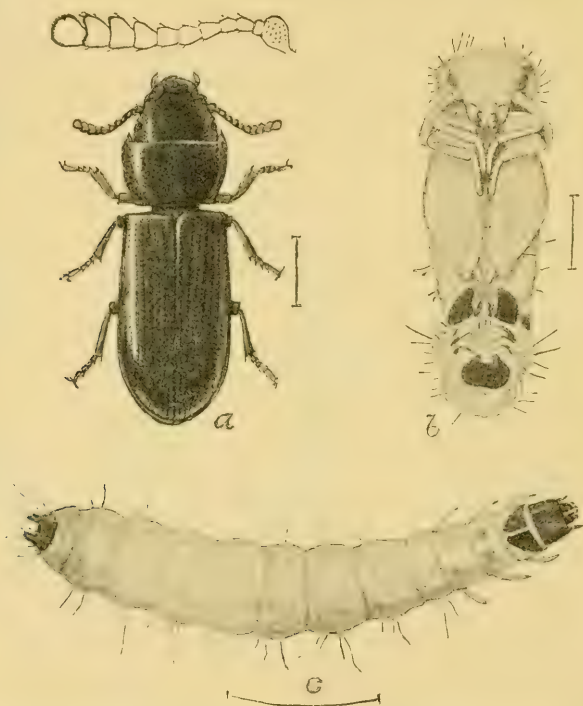


FIG. 18.—*Tenebroides mauritanicus*: a, adult beetle with greatly enlarged antenna above; b, pupa; c, larva—all enlarged (author's illustration).

The adult beetle, shown at fig. 18, a, is an elongate, oblong, depressed beetle, nearly black in color, and about one-third of an inch in length. The larva (c) is fleshy and slender, and measures when full grown nearly three-fourths of an inch. Its color is dull whitish, with a dark-brown head. The three thoracic segments are also marked with dark brown, and the tail terminates in two dark horny points. The pupa (shown at b) is also white.

The statements of some of the earlier writers that this species is granivorous has been discredited by later authors. It has been experimentally proven by the writer, however, that the insect lives both in

the larval and adult conditions upon grain; and furthermore, that were the insect more prolific it would become a source of much damage to seed stock from its habit of devouring the embryo, or germ, going from kernel to kernel and destroying for germinating purposes many more seeds than it consumes. Both larvæ and beetles serve a good purpose by attacking and destroying whatever other grain insects they happen to encounter.

PARASITIC AND OTHER NATURAL ENEMIES.

It might be supposed that insects which live a retired indoor existence would be comparatively free from parasitic and other enemies, but such is not the case.

It has been estimated of the granary weevil that one pair in the course of a year would produce 6,000 descendants. The moths are still more prolific, and as there are six or more broods of some species annually it will be seen that if all the eggs of one individual and her offspring develop there would be produced in one year a whole myriad of the insects, sufficient to destroy many tons of grain.

Fortunately, there are several natural checks to the undue increase of these insects. One of them is a diminutive mite which preys upon various species. Spiders that inhabit mills and granaries entrap the moths, and in the field they are preyed upon by nocturnal insects as well as by birds and bats.

The grain weevils and the Angoumois moth are often parasitized, two or three species of chalcids flies having been recognized as the enemies of each. The flour and meal moths each have several parasites, and most other granary insects are known to have either parasitic or predaceous enemies.

The good work that is sometimes done by parasites in limiting the multiplication of their grain-feeding hosts is exemplified in a case cited of the Mediterranean flour moth having been destroyed by a parasite when other means had failed to dislodge it in the warehouses which it had invaded.

METHODS OF CONTROL.

The measures to be employed in the control of insects affecting stored products are both preventive and insecticidal. As an insecticide nothing answers the purpose so well as the bisulphide of carbon, which is a nearly perfect remedy against all insects that infest the storehouse. The remedies that will be discussed in the present circular, while intended primarily for use against insects in stored grain, have an almost equal value against all forms of animal life that occur in products that are dried and kept in storage.

PREVENTIVE MEASURES.

A limited number of insects, like the Angoumois grain moth in the extreme South, enter the grain in the field, and certain precautions are therefore necessary to prevent their access to the granary. This is

accomplished, first, by harvesting as soon as the grain is ripe; second, by threshing as soon afterwards as possible.

In the process of threshing or cleaning much infested grain is blown out with the chaff and dust, and the moths and many adult weevils are killed by the agitation which the grain receives; but the immature forms of these insects, concealed in the kernels as eggs, larvæ, and pupæ, are apt to survive this treatment, and further measures are necessary for their destruction.

For this purpose a quarantine bin is desirable, to be as nearly airtight as possible, in which the newly threshed as well as the infested or suspected grain can be fumigated with bisulphide of carbon, according to the directions given on page 22.

Fresh grain should not be exposed to insect attack by being placed in bins with "weeviled" grain, or even housed under the same roof with such grain. If before storing in buildings that have been infested, the old grain be removed, the bins thoroughly cleaned, floors, walls, and ceilings brushed and scrubbed, the chances of infestation will be reduced to a minimum. If the storehouse has been badly infested, a fumigation with bisulphide is necessary.

The recent appearance of that most pernicious of mill pests, the Mediterranean flour moth, on the Pacific Coast and in certain locations in the East, has made indispensable the use of the bisulphide of carbon and the quarantine bin, and has brought to the fore a number of mechanical devices for its control. One of these is called a "steam sweeper," and certain mills in neighborhoods that are infested with this moth are already equipped with it. A steam pipe is run under the ceiling of each floor, and at intervals of about 25 feet a steam cock is placed, to which can be attached a hose for steaming the spouts and other portions of the infested machinery and all parts of the mill. The flour moth, as is well known, causes much trouble when in the larva or "worm" state by crawling into the spouts and elevator legs, where they spin their webs and clog the apertures. The liability of danger from this source may be obviated by the substitution of metal for the wooden apparatus generally in use, and already a metal spout has been patented and a metal elevator leg been devised for the express purpose of preventing this and other injurious insects from establishing themselves in these portions of the mill. Another device, called the "elevator brush," has been called into use to prevent the larvæ from choking up wooden spouts and elevator legs.

In times when the Angoumois grain moth was so injurious in France a number of machines were devised for the treatment of infested grain. Into these the grain is poured and revolved while exposed to heat or subjected to a violent agitation which kills the contained insects.

Cleanliness will accomplish much toward the prevention of injury from warehouse pests, the cause of a great proportion of injuries in granaries, mills, elevators, and other structures where grain and feed are stored being directly traceable to a disregard of neatness. Dust,

dirt, rubbish, and refuse material containing sweepings of grain, flour, and meal are too frequently permitted to accumulate and serve as breeding places for a multitude of injurious insects.

The floors of the storehouse should be frequently swept, and all material that has no commercial value burned.

A certain amount of attention has always been given to the construction of the storehouse with a view to the exclusion of insects, and, with the advent of the flour moth, our modern mills are being fitted with reference to its peculiar habits.

The ideal farmer's granary, from the standpoint of insect ravages, should be built at some distance from other buildings and the rooms constructed so as to be as near vermin proof as possible. The doors should fit tightly, and the windows covered with frames of wire gauze to prevent the passage of insects. The floor, walls, and ceilings should be smooth, so as not to afford any lurking places for the insects, and it would be well to have them oiled, painted, or whitewashed for further security. A coating of coal tar has been strongly recommended for the latter purpose. Such measures are not an absolute necessity in cold and temperate climates, but in the more heated atmosphere of our Southern States whatever possible should be done to lessen the chances of damage.

One of the latest things in the way of grain storage in connection with mills is the adoption of steel tanks for this purpose, for an account of which the reader is referred to the American Miller of May, 1896. It is claimed that the tanks are air-tight and fireproof and that in them "grain can be kept intact from any and all the destroying elements for an indefinite time."

The value of a cool place as a repository of grain has been known of old, and a building in which any artificial heat is employed is undesirable for grain storage. The "heating" and fermentation of grain, as is well known, is a productive source of "weevil," and this should be prevented by avoiding moisture and by ventilation.

The storage of grain in large bulk is to be commended, as the surface layers only are exposed to infestation. This practice is particularly valuable against the moths, which do not penetrate far beneath the surface. Frequent agitation of the grain is also destructive to the moths, as they are unable to extricate themselves from a large mass, and perish in the attempt. The rice and granary weevils, however, penetrate more deeply, and, although bulking is of value against them, it is not advisable to stir the grain, as it merely distributes them more thoroughly through the mass.

Many remedies have been proposed for use against stored grain insects, mostly of impractical or doubtful utility, and a long list of such substances, which are chiefly of a supposed repellant nature, could be given. The few of these which might be of value must be used in large quantity and in tight receptacles to be effective.

The most effective deterrent is naphthaline, which when used in tight

receptacles is an almost perfect preservative of seed stock and other products subject to insect attack. Its use is not, however, desirable with material that is to be used as food on account of its powerful and permanent odor. Salt, air-slaked lime, and powdered sulphur also serve the same purpose, but their use is also objectionable for different reasons.

INSECTICIDES AND OTHER DESTRUCTIVE AGENCIES.

Prior to the adoption of the bisulphide of carbon as a fumigant, heat was relied upon in the destruction of these insects. A temperature of from 125° to 140° F., continued for a few hours, is fatal to grain insects, and wheat can be subjected to a temperature of 150° for a short time without destroying its germinating power. Kiln-drying, at a still lower degree of heat, has been found effective.

A low temperature is equally destructive, and in colder climates these insects may be successfully dealt with by stirring or turning the infested grain, or by filling the buildings with steam and then throwing open the windows at night and exposing the insects to frost.

Steam, as has been said, is in successful use against the flour moth, and is employed in the same manner as bisulphide of carbon for the disinfection of bags and machinery in the quarantine box.

Sulphur, properly applied, may be used with benefit when for any reason the use of bisulphide is not advisable, and sulphur combined with steam is particularly destructive to insect life. Its use, however, is attended with certain disadvantages, necessitating the removal of all grain, as the former is apt to be injured for flour-making and the latter for bread-making purposes.

Benzine and naphtha or gasoline are of some value as fumigants for some materials, but do not produce entirely satisfactory results with grain, their vapors being insufficient for the destruction of the adolescent stages of species which breed wholly within the kernel, while each of these reagents possesses an offensive and more or less persistent odor. They are open, moreover, to the same objections as bisulphide of carbon, the vapor being about equally inflammable and more explosive.

THE BISULPHIDE OF CARBON TREATMENT.

The simplest, most effective, and inexpensive remedy for all insects that affect stored cereal and other products is the bisulphide of carbon, a colorless liquid with a strong, disagreeable odor, which, however, soon passes away. It vaporizes abundantly at ordinary temperatures, is highly inflammable, and is a powerful poison.

It may be applied directly to infested grain or seed without injury to its edible or germinative principles by spraying or pouring, but the most effective manner of its application in moderately tight bins or other receptacles consists in evaporating the liquid in shallow dishes or pans, or on bits of cloth or cotton waste distributed about on the surface of the infested material. The liquid rapidly volatilizes, and

being heavier than air descends and permeates the mass of grain, killing all insects and other vermin present.

The bisulphide is usually evaporated in vessels containing one-fourth or one-half of a pound each, and is applied in tight bins at the rate of a pound to a pound and a half to the ton of grain, and in more open bins a larger quantity is used. For smaller masses of grain or other material an ounce is evaporated to every 100 pounds of the infested matter. Bins may be rendered nearly air-tight by covering with cloths, blankets, or canvas.

Infested grain is generally subjected to the bisulphide treatment for twenty-four hours, but may be exposed much longer without harming it for milling purposes. If not exposed for more than thirty-six hours its germinating power will not be impaired. In open cribs and badly infested buildings it may sometimes be necessary to use a double quantity of the reagent and repeat treatment at intervals of about six weeks during the warmest weather.

Mr. H. E. Weed, entomologist of the Mississippi Experiment Station, claims that 1 pound to 100 bushels of grain is amply sufficient to destroy all insects, even in open cribs.

Mills and other buildings, when found to be infested throughout, may be thoroughly fumigated and rid of insects by a liberal use of the same chemical. A good time for this work is during daylight on a Saturday afternoon or early Sunday morning, closing the doors and windows as tightly as possible and observing the precaution of stationing a watchman without to prevent anyone from entering. It is best to begin in the lowest story and work upward, to escape the settling gas. The building should then be thoroughly aired and the grain stirred early Monday morning.

For the fumigation of a building or a reasonably close room it is customary to evaporate a pound of the bisulphide for every thousand feet of cubic space. In comparatively empty rooms, and in such as do not admit of being tightly closed, two or three times the above quantity of the chemical is sometimes necessary.

Certain precautions should always be observed. The vapor of bisulphide is deadly to all forms of animal life if inhaled in sufficient quantity, but there is no danger in inhaling a small amount. The vapor is inflammable, but with proper care that no fire of any kind, as, for example, a lighted cigar, be brought into the vicinity until the fumes have entirely passed away, no trouble will be experienced.

Bisulphide of carbon retails at from 20 to 30 cents a pound, but at wholesale, in 50-pound cans, may be obtained for 10 cents a pound. A grade known as "fuma bisulphide," for sale at the latter price, is said to be more effective than the ordinary commercial article.

At the rate used the cost of treatment is from 10 cents and upward for each ton of grain.

SUMMARY OF PRINCIPAL REMEDIES AND PREVENTIVES.

The bisulphide of carbon by reason of its intensive action is the best known remedy against all insects that affect stored products, and for this purpose is becoming indispensable, but in addition to its use various other measures, principally preventive, may be observed with profit for the preservation of grain against insect attack. The principal coordinate or additional measures may be summarized as follows:

(1) Prompt threshing to prevent the Angoumois grain moth, rice weevil, and some other species in the extreme South, from obtaining access to the granary.

(2) Inspection, quarantining, and disinfection of infested or suspected grain, bags, and machinery before permanent storage.

(3) Scrupulous cleanliness, including the prompt destruction of refuse material, which will accomplish much in lessening the chances of injury.

(4) Constructing or refitting the warehouse or mill, especially in warm latitudes, with a view to the exclusion of insects.

(5) Substitution of metal, for wooden, spouts, etc., and the use of other improved machinery in mills infested with the flour moth.

(6) Storage in large bulk, particularly valuable against grain moths.

(7) Storage in a cool, dry repository, well ventilated to prevent "heating."

(8) The use of naphthaline as a preservative of small samples in tight receptacles.

INVESTIGATION OF INSECTS AFFECTING STORED PRODUCTS.

The Division of Entomology is engaged in a special investigation of the insects that infest stored products, including grain, flour, meal, patented foods, peas, beans, dried fruits, nuts, seeds of different kinds, herbs and dried plants, drugs, leather, dried meats, woolen and other fabrics, specimens of natural history, etc.

Information is desired of anything new or of unusual interest, and correspondence is invited. Communications should be accompanied where possible by specimens of the insects concerned, with full statements regarding the extent of the injuries. Such facts as may be gathered through correspondence will be reserved for publication if of sufficient value, but the names of correspondents and of localities infested will be withheld unless permission is given for their use in this connection.

The person to whom this bulletin is sent is respectfully requested to bring the matter to the attention of some farmer, miller, or grocer or other merchant of his neighborhood who may suffer from the presence of these insects in his granary, mill, or storehouse and who may desire advice in regard to the best methods of controlling them.

The experience of persons who have had an opportunity to test on a large scale the bisulphide of carbon and other remedies for stored-product insects is also solicited.

Address: Division of Entomology, U. S. Department of Agriculture, Washington, D. C.

DIV. INSECTS.
U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 47.

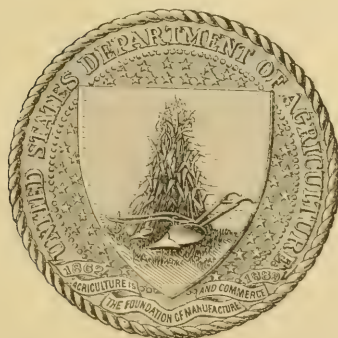
INSECTS AFFECTING THE COTTON PLANT.

BY

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ENTOMOLOGIST.

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INSECTS AFFECTING THE COTTON PLANT.

THE COTTON WORM, OR COTTON CATERPILLAR.

(*Aletia argillacea* Hübn.)

GENERAL APPEARANCE, HABITS, AND LIFE HISTORY.

This insect is perfectly familiar to all cotton growers. The slender, bluish-green caterpillar with small black spots, and often with black stripes down its back, which loops when it walks and feeds voraciously on both upper and under surfaces of the cotton leaf, is to be found in cotton fields in the Gulf States all through the summer. It is generally not noticed in the early part of the season on account of its insignificant numbers. Later, through the ragging of the leaves, it becomes noticeable, and in seasons of abundance the plant is entirely defoliated. Farther north the insect makes its appearance at a later date in the season, and there the caterpillars are not the offspring of hibernating moths, but of the moths of the first or second generation, which have developed in more southern cotton fields and have flown north with the prevailing southern winds. Late in the season moths of the fourth or fifth generation fly far to the north, frequently making their appearance in numbers about electric lights in Canada. There is no absolute evidence of any other food plant than cotton, although many entomologists have surmised that the species has a northern food plant. The specimens seen in Canada have, however, in all probability flown north from cotton fields in the Carolinas, and perhaps even farther south.

The egg.—The egg is bluish green in color and of a different shade from that of the leaf, so that it can be rather readily distinguished. It is flattened-convex in shape, with many parallel longitudinal ridges converging at the center above. It is found usually on the under side of the leaves and as a general thing toward the top of the plant. In the neighborhood of 500 eggs are laid by each female, sometimes several upon one leaf, but never in clusters. The eggs are laid at night, since the moth is a night flyer. The duration of the egg state varies somewhat, according to the season. In midsummer the larva hatches in from three to four days after the egg is laid, but in spring and autumn this period is very considerably lengthened.

The larva.—After hatching from the egg, the young larva feeds at first upon the under side of the leaf, devouring simply the lower parenchyma and not piercing through to the upper side until after the first

molt. At first the larva is pale yellow in color, soon becoming greenish. The dark spots become more or less conspicuous after the first molt, and the characteristic markings, as shown in the figure, make their first appearance. After the second molt these markings become more conspicuous, and the insect takes on a distinctly greenish color, the black along the back varying among different individuals in its intensity. Before reaching full growth the caterpillar sheds its skin five times, and the duration of the caterpillar stage is from one to three weeks. Early in the season the green color appears to predominate, while toward the fall the blackish caterpillars are more abundant, although at any time during the season

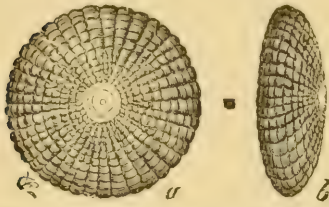


FIG. 1.—Egg of cotton worm moth: a, top view; b, side view—greatly enlarged (from Fourth Rept. U. S. Entom. Comm.).

green and dark worms are seen together. Although the normal food of the caterpillar is the leaves, it will frequently gnaw the tender twigs and will even damage the bolls by eating into them in spots. This, however, generally occurs only when the worms are present in exceptional numbers and the supply of leaves becomes exhausted. We have referred to the fact that the caterpillar is a looper, i. e., that it walks by bringing its hind prop legs up to the true legs, causing its back to arch up in a loop. Like the true loopers, or measuring worms, it has the habit of jerking itself some little distance when disturbed, and when it falls it usually supports itself by a silken thread. It is something of a cannibal, and when other food fails, or even rarely when leaves are abundant, it will feed upon smaller and feebler individuals of its own kind. In spite of its comparatively small size and slender form, this larva is, in fact, very voracious, and when occurring in numbers the ruin which it accomplishes is complete.

The chrysalis or pupa.—The caterpillar, having become full grown, never enters the ground to transform, although many planters have believed that this is the manner in which the insect passes the winter. It spins a light silken web, forming an imperfect cocoon, usually within a folded leaf. It is frequently seen hanging quite naked upon the plant, but in such cases the leaf in which it was originally spun has been eaten away by other caterpillars. Its color is at first green, but

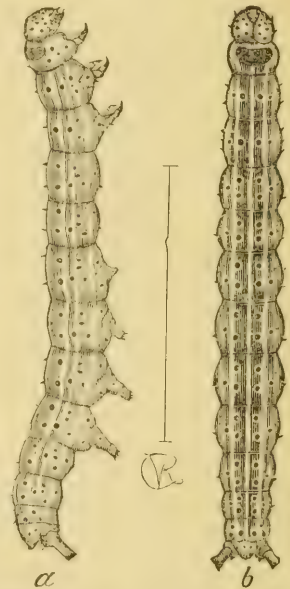


FIG. 2.—Cotton caterpillar: a, from side, b, from above—twice natural size (from Fourth Rept. U. S. Entom. Comm.).

in the course of an hour or so it changes to brown. The insect remains in this condition for a period varying from one week to thirty days.

The adult insect.—The perfect insect or imago of the cotton caterpillar is a rather small moth of an olive-gray color, sometimes with a somewhat purplish luster. Its wings expand from $1\frac{1}{8}$ to $1\frac{1}{2}$ inches. The markings of the wings are indicated in the figure. The moth is a night flyer and hides during the day, starting up and flying with a swift, somewhat darting motion when disturbed. After sunset it takes wing and flies about, laying its eggs or searching for food. It feeds, in fact, rather extensively, frequenting neighboring flowering plants and also the nectar glands of the leaves of cotton. Fruit, as it ripens, also attracts these moths, and is frequently seriously injured by them. The tongue or proboscis of the moth is curiously modified and fitted for piercing the skin and tissues of ripe fruit. It is said that they are able to puncture hard green pears, the effect of the puncture being a discoloration of the skin for some distance around. The female begins to lay her eggs in from two to four days after leaving the chrysalis, and each individual lays from 300 to 600 eggs. With five consecutive and rapidly developed generations the occasionally extraordinary numbers of the late broods are not to be wondered at.

Number of broods or generations.—The observations of Mr. Schwarz in south Texas in 1879 show that at least seven, and probably even

more, generations are produced there. Fully as many probably develop in Florida. The general belief in the South up to the time of the beginning of the cotton-worm investigation was that there were three generations only, since three "crops" of worms only were customarily observed. The early generations, however, were overlooked on account of their small numbers, and, in fact, in the northern portions of the cotton belt the general idea was correct enough, since northward-flying moths in general do not oviposit in fields in this region until comparatively late in the season. The moths hibernate only in the extreme southern portions of the cotton belt, as will be shown in the next section, and begin to lay their eggs as early as March, or perhaps even earlier, in south Texas and Florida. Two generations are rapidly developed, and then, in these localities, a confusion of generations commences on account of the retardation of development in certain individuals and acceleration in certain others. Moths from the end of March on are constantly flying out from these points and, carried by the prevailing southerly winds, settle in more northern fields and stock a certain number of plants with eggs. Moths developing from caterpillars hatching from these eggs in turn stock the fields in which they



FIG. 3.—Cotton worm moth: *a*, with wings expanded in flight; *b*, wings closed, at rest—natural size (after Riley).

have developed with a greater number of eggs, and a certain proportion of them fly farther north. In this way there is a progressive development all through the cotton belt and a somewhat varying number of generations in different localities. Under certain conditions, however, such as the early development of a very large brood in the far South, so many moths may be developed that there is a nearly simultaneous stocking of a very extensive region.

The importance of ascertaining the early presence of the worms, although in small numbers, from a remedial point of view, is very great, and since it was conclusively shown that worms may be found in the fields in the Gulf States long before the so-called "first crop," planters have looked for them more carefully, and doubtless in many cases possibly severe injury has been prevented by the poisoning of early worms.

The moths of the last generation in seasons of cotton-worm abundance frequently make their appearance in numbers far north. The moth is a very strong flyer, and, aided by the wind, has been known to occur abundantly in Canada, and has been observed in numbers far out at sea. During September it has been known to do very considerable injury to peaches in Kansas and to ruin acres of cantaloupes as far north as Racine, Wis.

Method of passing the winter.—The greatest difficulty was found in settling the question as to the manner in which this insect passes the winter, but it has finally been established that over the more northern portion of the cotton belt the species dies out every year, while in the more southern portions the moth hibernates and remains torpid in sheltered situations. There must also have been occasionally an ingress of moths from outside of the United States, say from the West Indies or from Mexico or Central America. It was undoubtedly in this way that the species was first introduced into the United States, and such immigrations were probably of frequent occurrence down to comparatively recent years. Professor Riley, writing in 1882, concluded that there is nothing more fully established than that the moth hibernates principally under the shelter of rank wire grass in the more heavily timbered portions of the South, and that these moths begin laying on the ratoon cotton when it is only an inch or so high. Only the exceptional few survive, and this survival seems to be more common in the western part of the cotton belt than in the Atlantic States.

PARASITES AND NATURAL ENEMIES.

In the report by Professor Comstock, published in 1880, and in the Fourth Report of the United States Entomological Commission much space is devoted to the subject of the natural enemies and parasites of the cotton worm. They are very numerous, and without their aid the worms must have done infinitely more damage than they have accomplished; but, practically speaking, we need devote no space to their detailed consideration, as they can not be practically handled. Their increase can not be encouraged beyond the enforcement of gen-

eral laws against the killing of insectivorous birds. Two of the most important of the parasitic insects are shown in the accompanying figures. The little egg parasite, *Trichogramma pretiosa*, a species which is so minute that several specimens live within a single egg of the cotton moth, is one of the more important. Mr. Hubbard has recorded the fact that in Florida this one parasite almost entirely annihilated the fifth brood. At the beginning of the fourth brood about half of the eggs were destroyed by this insect. Of the eggs laid by the fourth-brood moths, from 75 per cent to 90 per cent were parasitized, while of the eggs of the fifth brood the proportion destroyed by the parasite exceeded 90 per cent, and out of the sixth brood careful estimates show that but 3 or 4 eggs out of 100 escaped. The external parasite of the caterpillar, *Euplectrus comstockii* (fig. 4), is also another abundant parasite, while the other insects figured take almost as important parts in limiting the increase of the worm. As far back as 1847 Dr. D. B. Gorham found that nearly all of the chrysalids of the last brood of worms were destroyed by *Pimpla conquisitor* (fig. 5). From this fact he argued that the fields must be restocked by moths flying up from the south, and perhaps from the West Indies. It is a very curious fact that some twenty-five years later Mr. A. R. Grote, studying the cotton worm in Georgia, was unable to find any parasites whatever, and from this fact argued that the insect was not a normal member of the Georgia fauna, but flew in every year, probably from the West Indies.

REMEDIES.

In the Fourth Report of the United States Entomological Commission nearly 200 pages were given to the consideration of remedies and preventive measures. All the false ideas which had gained currency among planters were explained away, an extensive consideration of remedies against the insect in all stages was given, and the subject of machinery for the distribution of wet and dry poisons was most elaborately treated. The chapters on remedies in this report have resulted in great benefit to the agricultural community as a whole. The system of eddy-chamber or cyclone nozzles was here first treated, and modifications of these nozzles are now in active use in all parts of the world for the application of insecticides and fungicides to very many crops. Several elaborate machines for the distribution of wet poisons were invented in the course of the investigation, and all devices which had been patented received consideration. Although, as just stated, this work has been of great value to agriculture and horticulture at large, its results from the standpoint of the cotton grower have, for various reasons, amounted practically to nothing down to the present time.

In 1883 Dr. W. S. Barnard, who had been in charge of the insecticide



FIG. 4.—Skin of cotton caterpillar attached to the under side of cotton leaf by silk spun about the pupæ of *Euplectrus comstockii*—natural size (from Fourth Rept. U. S. Entom. Comm.).

machinery portion of the cotton-worm investigation, was sent to Alabama to make field tests of the largest and apparently most practical machines which had been devised. He found that the large machines, so arranged as to underspray sixteen rows of cotton at once, were comparatively impractical, except in a very few cases. Were cotton so planted that the rows were equally spaced the machine would work very well, but the inflexibility of the larger machines prevented them from conforming to inequalities of the ground and to uneven rows. Every cotton planter knows that in an average cotton field the necessities of the case will not allow of ideally true rows. The rows must run wider or narrower according to the quality of the soil and the size of the plant a certain soil will produce. It was found, therefore, that an attempt to underspray more than four rows at once was practically useless.

Such extensive remedial work against this insect as was planned in the Fourth Report of the United States Entomological Commission

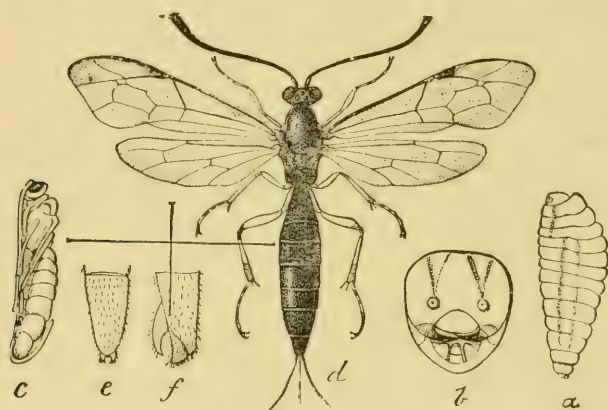


FIG. 5.—*Pimpla conquisitor*, one of the principal parasites of the cotton caterpillar: a, larva, enlarged; b, head of same, still more enlarged; c, pupa; d, adult female, enlarged; e, f, end of abdomen of adult male, still more enlarged (from Fourth Rept. U. S. Entom. Comm.).

has not of late been found necessary in the South. Perhaps the main reason is that a change has taken place in Southern agriculture, which has frequently been urged by writers upon economic entomology as most conducive to the limitation of wide-spread damage by any given species of injurious insect.

This is the greater diversification of crops. Cotton is no longer planted everywhere, as in the broad fields which were so common twenty years and more ago. As a characteristic instance, we may take the case of a prominent planter at Columbus, Tex., who in 1880 had 500 acres of cotton under cultivation in a bend of the Colorado River. In 1894 he had of the same area 300 acres in corn, 100 acres in Johnson grass, and only 100 acres in cotton. It is readily seen that such a breaking up of the immense cotton fields of the South will to a great extent prevent any undue multiplication of the caterpillars and consequent migration northward of the moths. Twenty years ago, moreover, remedial work on a large scale was not attempted by cotton planters. Later the knowledge of the importance of poisoning for the early broods has inspired planters with a feeling of confidence, which has since steadily grown, both as the result of successful remedial work on a more or less small scale and the undoubtedly smaller numbers of the worms.

Further, the development of the cotton-seed oil industry has been an important factor. In earlier times rank-growing varieties of cotton, producing few seeds, but of long fiber, were grown. Now that cotton seed is worth from \$9 to \$15 a ton, smaller varieties of cotton, with a shorter fiber and a higher proportion of seeds, are more popular. The fields are thus more open, and not only afford a better opportunity for remedial work when necessary, but also show plainly the first "ragging" of the leaves and prevent the worms from working in numbers comparatively out of sight until one or more generations have developed and the moths have become sufficiently numerous to lay eggs for the old and greatly feared "third brood." These points and others have already been reported by Mr. E. A. Schwarz, of this office. His article is a result of observations made upon an official trip through the cotton belt in the summer of 1894. At many points he found the sentiment among planters to be that the cotton-worm question is solved. As a result of these observations and of the reports of Professor Atkinson in Alabama and Professor Tracy in Mississippi, as well as from conversations had with a number of influential cotton planters and correspondence with others, we are quite inclined to believe that the simple method of using undiluted and dry paris green powder which has sprung up throughout the South is probably capable of maintaining present conditions. So far as we know, the large machines recommended in the Fourth Report of the Entomological Commission have never been built and operated by planters.

The distribution of dry paris green from two bags held at the ends of a pole over the back of a horse or mule is a process which has developed apparently spontaneously. At least ten years ago the process was described to the author in a conversation with Hon. Charles E. Hooker, Member of Congress from the Seventh district of Mississippi. Writing in July, 1890, Prof. G. F. Atkinson, of Alabama, spoke of it as a "recent" method. The Mississippi Experiment Station, in June, 1890, described the method as one which had been recently developed. Prof. J. S. Newman, of Auburn, Ala., used the process as early as 1887. It is quite probable, however, that this method dates back to early in the seventies. The method is described by the Mississippi Experiment Station as follows:

Make two sacks of heavy cloth, each about 10 inches long and 4 in diameter, open the whole length of one side and firmly sewed at the ends. We have found 8-ounce osnaburg the best cloth for the purpose. Take a strip of oak or other strong wood about $1\frac{1}{2}$ by 2 inches and 5 feet long, and bore a 1-inch hole 5 inches from each end. Tack one of the sacks to each end of the pole, fastening one of the edges of the opening to each of the narrow sides of the pole.

The sacks can be filled by pouring the poison through a funnel inserted in the holes through the pole, and distributed by riding on horseback through the cotton rows, dusting two rows at a time. A little practice will enable one to do this work very evenly, and care must be taken not to allow the sacks to touch the leaves when wet or the poison will not pass through. When the sacks are freshly filled a very slight jarring will shake out a sufficient amount of the poison, but when nearly

empty the pole should be frequently and sharply struck with a short stick, or spaces in the rows will be missed.

When used in this way we have found it the best plan to use the poison without any admixture of flour, and if flour is to be added lighter cloth should be used in making the sacks.

With a pole and sacks as described, one man and mule can poison from 15 to 20 acres per day.

THE COTTON BOLLWORM.

(*Heliothis armiger* Hübn.)

Unlike the cotton worm, this insect is by no means confined to America, nor is it confined to cotton as a food plant. It is known in many other parts of the world, and it can not be surmised at the present time whether it has been carried from some one point or whether it is indigenous over its extremely wide range. Its food plants vary in an extraordinary degree. In this country it is one of the principal enemies of cotton, of corn, and of the tomato.

The cotton bollworm, the corn earworm, and the tomato fruit worm are all the same species. In addition to these crops, it feeds upon peas and beans, tobacco, pumpkin, squash, okra, and a number of garden flowering plants, such as cultivated geranium, gladiolus, mignonette, as well as a number of wild plants.

GENERAL APPEARANCE, HABITS, AND LIFE HISTORY.

The egg.—The egg is a little larger than that of the cotton worm and more nearly globular. It is nearly white in color but rather inclined to yellowish. Examined with a lens, its sculpturing seems to be almost identical with that of the cotton worm. The eggs are laid upon all parts of the cotton plant, occurring most abundantly on the under side of the leaf. A few can be found upon the stalks, many upon the upper surface of the leaves, some upon the involucre, and occasionally they are seen upon the stems of the boll or upon the petiole of the leaf. The eggs are laid just at twilight, and they hatch in from two days to a week.

The larva.—When first hatched, the bollworm looks much like the cotton worm. It is rather darker in color, but also walks like a looper, or measuring worm. It feeds at first near the eggshell, and then begins to wander away, crawling from one leaf to another, until a young bud or boll is found, into which it bores. Frequently several days pass in this search for a boll, and rarely the worm may reach full growth upon a diet of leaves. It is during this early, wandering, leaf-feeding existence that the insect may be destroyed by arsenical poisons, as is true of the cotton worm. When the young worm enters the flower bud the involucre flares open and the young bud or young boll finally drops. This "shedding" of cotton is, however, not caused by the bollworm alone. Other insects are concerned in the damage, and the flaring and dropping occasionally occurs when no insect injury can be found. A very considerable amount of damage may be done in this way, as a single



FIG. 6.—Transformations of cotton bollworm: 1. Egg on under side of cotton leaf; 2. Larva one-third grown boring into square; 3. Entrance hole of young larva in square, with excremental pellets at edge of hole; 4. Nearly full-grown larva just issued from boll; 5. Full-grown larva on leaf stem; 6. Pupa shown in center of underground earthen cell; cell shown in longitudinal section; 7. Adult moth, light variety; 8. Adult moth with dark forewings; 9. Adult moth in resting position, wings slightly elevated.

young larva will travel from bud to bud, deserting each before it falls. The bud pierced just before opening is forced into premature bloom, but the worm usually feeds upon the stamens and pistil, rendering it incapable of fructifying. As the bollworms grow, they begin to vary greatly in general appearance. Full-grown worms may be found of almost every intermediate stage of color between light green and dark brown or rose. They may be unstriped and unspotted, or they may possess dark stripes or black spots. These color varieties are not caused by different food, since many variations occur in specimens feeding upon the same plant. Upon cotton the larger worms take the larger bolls, the young ones having confined themselves in the main to the flower buds and the newly formed bolls. They then practically progress downward, the young ones being found mainly upon the top crop, while the older ones bore into the older bolls of the middle crop, the bottom crop being seldom seriously damaged by this insect. Often a single worm will practically destroy several large bolls, and one instance is on record where 18 young bolls and many blooms and unopened flower buds have been destroyed by one not fully grown worm. The bollworm is not only a voracious plant feeder, but it is also a cannibal. Older worms feed upon younger ones, and it has often been known to eat the chrysalids of the cotton caterpillar. With an abundance of vegetable food at hand, the larger worms will seize upon their small brothers, biting through the skin and feeding upon the juices of the body. In ears of corn the remains of several young worms are often found, while the strong, large worm which has destroyed them is the only living occupant of the ear. The larva occupies from two weeks to a month in reaching full growth.

The pupa, or chrysalis.—Unlike the cotton caterpillar, the bollworm enters the ground in order to transform. It forms an oval cell composed of particles of earth held together by a loose, gummy silk, or the pupa may be perfectly naked. It is of a light mahogany color, darker toward the head, and the duration of this state is from one to four weeks.

The adult insect.—The adult insect of the bollworm is a moth about the size of the cotton-worm moth, but has a stouter body and is more extensively marked, as well as more variable in its markings. Its general color varies from a dull ocher-yellow to a dull olive-green. The fore wings have a rather dark band near the tip and the hind wings are also bordered with a darker band. The wing veins are lined with black and the fore wings have also several dark spots. There is great variation in these markings, and they are intensified in some individuals and almost lacking in others. When the moth is at rest, the fore wings are slightly open, whereas in the cotton-worm moth they are closed in a roof-shaped manner. The moth flies normally about dusk, lays about 500 eggs, and is not a fruit feeder like the cotton-worm moth. During the day they hide in cowpeas and in clover, when these grow near the

cotton field, and fly low with a quick darting motion when disturbed. About sunset they begin to feed upon the honey secreted by the cow-pea and blossoms of clover, as well as upon the nectar of the cotton plant and other honey-secreting plants. Mr. Mally speaks of seeing the moths eating at 3 o'clock in the afternoon, and Mr. Mullen states that he has noticed them feeding freely during all hours except the early morning hours, and during 1892 noted them particularly depositing their eggs in broad daylight.

Number of generations.—The average time occupied by the insect in its transformations from egg to the adult is about thirty-eight days. The number of annual generations is about five. In the cotton-growing States the worms of the first three generations feed usually in the corn-fields. In fact, in choice of food plants, cotton seems to be secondary to corn. They feed upon corn by preference until this becomes too hard to be readily eaten. The worms of the first generation make their appearance the latter part of April or early in May, and feed almost exclusively upon the leaves and terminal buds of corn. The second generation, appearing in early June, feed upon the tassels and forming ears of corn, while the third appears in July and feeds upon the hardening corn. When the fourth generation appears, the corn has become too hard for appropriate food, and the moths therefore fly to neighboring cotton, which carries at that time plenty of tender young bolls. A few worms will have been found upon cotton before this time and will have fed upon the leaves and flower buds only in the absence of bolls. Others will have been found upon tomatoes, if these are grown upon the plantation, while still others have been feeding upon cowpeas. As a general thing, bollworms are seen in force upon cotton about the first of August, and usually these individuals belong to the fourth generation. The fifth generation makes its appearance about the middle of September, and about the middle of October, or even earlier, the caterpillars enter the ground for transformation to pupæ.

Hibernation.—The bulk of the bollworms hibernate in the pupa state underground. In a warm fall the moths have been known to issue during the month of November, and Mr. Mally has shown that frequently a few moths hibernate. These hibernating moths appear and begin laying eggs much earlier than the moths which issue from overwintered pupæ. This results in something of a confusion of generations the following season, and at Shreveport, La., Mr. Mally found a series of small broods along with the more or less regular large ones, a sixth generation of worms appearing a little later in the fall and hibernating in the pupa state. In evidence of this fact he adduces the finding of young bollworms as late as November 20. Young and old worms may, in fact, be found simultaneously after the middle of May. Mr. Mally's observations, however, extended through two seasons only, and this state of affairs may be exceptional, particularly as the winter of 1890-91, when he made his observations, was unusually mild in Louisiana and

the spring earlier than usual. In Arkansas four or five generations are found in the northern and southern portions of the State, while in southern Texas six generations and a partial seventh seems to be the rule. The determination of the time of the appearance of the several generations of moths for each differing locality is of very considerable importance, and can only be made by local observers. It is of importance in arranging for the trap-crop method of protecting cotton, which will be discussed under the head of remedies.

NATURAL ENEMIES.

The bollworm has by no means as many natural enemies as the cotton caterpillar. The latter insect feeds exposed upon the leaves, and is therefore subject to the attacks of predaceous and parasitic insects, as well as birds. The bollworm, however, as a general thing, feeding in the interior of the cotton boll, or ear of corn, or fruit of tomato, or pea or bean pod, is not readily found. In fact, although birds have been noticed to feed upon it, it was long considered to be absolutely free from true parasites. Riley, however, bred a *Tachina* fly from the larva, and Hubbard reared the little egg parasite *Trichogramma pretiosa* from the bollworm eggs in Florida. The more recent investigations of Mally have resulted in finding four additional parasites. One of these is an egg parasite of the genus *Telenomus*. Another is a species of *Limneria*, while the other two are the common *Euplectrus comstockii* How. and *Chalcis ovata* Say, which are such abundant parasites of the cotton worm. The hairy or downy woodpeckers are frequent visitors of cornfields and have been seen to extract the worms from infested ears.

REMEDIES.

Lights for trapping moths.—This is one of the remedies which have been most often advised, and has been very extensively used in parts of the South, particularly in Texas. In view of this fact, Mally, during his two summers' investigations, made extensive experiments with trap lights for the moths. He has carefully tabulated all the insects which were captured in this way. A few bollworm moths were caught, but these apparently by accident, and a thoroughly unprejudiced conclusion from his experiments must be that the use of lights for attracting and trapping bollworm moths is without beneficial result. The other insects caught by the light were found to be about evenly divided between those which are beneficial and those considered injurious; but most of the insects called injurious are of no especial economic importance in the cotton region and should be omitted from consideration in forming conclusions. The use of lights, from the cotton-grower's standpoint, is really a disadvantage, and money expended in this practice is without doubt entirely lost.

Poisoned sweets.—Together with the use of lanterns for attracting the moths, poisoned sweets have been recommended for many years.

Mally also experimented in this direction and found that a modification of this remedy is more or less effective. He advises the planting of a few rows of cowpeas as a trap bordering the cotton fields. They should be planted so late as not to reach the height of blooming before the destructive August brood appears. A portion of the row should be sprayed over every night with a mixture of 4 ounces of beer to 2 ounces of potassium cyanide solution. The moths will be attracted by this mixture and will be destroyed by it. The mixture dries readily, and hence if applied in the afternoon will not result in the destruction of any day-flying beneficial insects.

Poisoning the worms.—The careful study which has been made of the natural history of the bollworm, particularly that by Dr. William Trelease, in Alabama, in 1880, shows that where arsenical poisons are applied for the so-called third brood of the cotton worm, about August 1, many bollworms are destroyed. It is about this time that many young worms are hatching from the eggs and feeding for a longer or shorter space of time on the leaves before entering the bolls. It was therefore thought at the time when Comstock's report on cotton insects was written that the poisoning for the cotton worm, which was so strongly recommended and which was so necessary under the conditions governing at that period, would largely reduce bollworm injury. In fact, as we have shown in our opening paragraph, the bollworm itself at that time was by no means such a factor in cotton growing as it is at the present time. With the great reduction of damage done by the cotton worm and the great increase of that done by the bollworm, however, poisoning for the cotton worm has become comparatively rare, and on account not only of the greater abundance of bollworms, but also of the consequent greater confusion of generations of this insect, and the fact that not more than half at the outside could be destroyed by poisoning at any one given time, this method has largely lost its former value as a bollworm remedy.

Trap crops.—In the intelligent handling of trap crops the cotton planter will find by far the most efficacious preventive of bollworm damage. This suggestion is an old one. It was proposed by Sorsby in 1855, by E. Sanderson in 1858, and by Peyton King in 1859. It was recommended by Comstock after careful preliminary observations by Trelease in 1879, and Riley in 1885 gives it at least equal rank as a remedy with poisoning. The complete development of the trap-crop system, however, rests upon the studies and recommendations made by Mally; and S. B. Mullen, of Harrisville, Miss., has written in a most practical manner relative to corn. Mally's recommendations are, in brief, when planting cotton leave vacant strips of 5 rows for every 25 of cotton. In these 5 rows, at the earliest possible time, plant 1 row with an early maturing sweet corn. It should not be drilled in too thickly, as a minimum number of plants and ears is desired. During the silking period frequent careful examinations must be made as to the

number of bollworm eggs. As soon as no more fresh white eggs are found each morning, the silk ends of the corn should be cut away and burned or fed to stock in order to destroy the young worms and the eggs. A few eggs may also be found upon the leaves of the plants, and since no more growth is to be made the plants should be cut and destroyed. Then 3 more of the rows should be planted to dent corn at such a time as to bring the silking period about the 1st of July or a little later. Upon these rows very large numbers of eggs will be laid, but they should be allowed to mature in order that the natural enemies which parasitize the eggs and prey upon the larvæ may not be destroyed. The crowded condition of the worms in the ears developed in these 3 rows will induce cannibalism to such an extent that the number of worms reaching maturity will be reduced to the minimum, and these can well be allowed to escape if the natural enemies are saved thereby. To trap these escaping individuals, however, the fifth and last row of the vacant strips should be planted to sweet corn at a time which will allow it to reach full silk about August 1, since the majority of the moths begin issuing again about that time. This last row should be carefully watched, and the corn should be cut and destroyed as soon as it appears that no more eggs are being deposited. Mr. Mally found that the corn produced by the second planting is likely to be large enough in quantity to pay for expense of cultivation and the sacrifice made by cropping the 5 rows in corn instead of cotton. Moreover, he thinks that if the first two plantings are well managed the earlier broods of the bollworm will be so reduced in numbers that the August brood will not be capable of inflicting great injury, and therefore in the less-infested regions the third planting may be dispensed with. He further found that it was not necessary to crop the entire plantation with this 5 to 25 rows of corn to cotton. If 5 acres be planted in this way for every 50 acres of cotton, or even 5 acres of trap alternate for 75 or 100 acres, the crop of the entire plantation may be protected.

THE MEXICAN COTTON-BOLL WEEVIL.

From the present outlook the most important of the insects which damage the cotton boll, next to the bollworm itself, is the cotton-boll weevil (*Anthonomus grandis* Boh.).

GENERAL APPEARANCE AND METHOD OF WORK.

This insect is a small, grayish weevil, of the shape and general appearance shown in fig. 7, *a*, and measuring a little less than a quarter of an inch in length. It is found in the cotton fields throughout the season, puncturing and laying its eggs in the squares and bolls. The larvæ, of the shape and appearance shown at fig. 7, *c*, and measuring a little over three-eighths of an inch in length when full grown, live within the buds and bolls and feed upon their interior substance.

The squares attacked usually drop, but most of the damaged bolls remain upon the plant and become stunted or dwarfed, except late in the season, when they either dry or rot.

DISTRIBUTION.

The insect through its ravages caused the abandonment of cotton culture around Monclova, Mexico, about 1862. Two or three years ago cotton was again planted in that vicinity, but the weevil immediately reappeared and destroyed the crop. At Matamoras the weevil was noticed eight or ten years ago. About 1893 it crossed the Rio Grande at Brownsville, Tex., and in 1894 was noticed in the country around San Diego, Alice, and Beeville. At the close of the season of 1894 the insect occupied a territory extending to the north a little beyond Beeville, a few miles to the east of that point, and southwest to the neighborhood of Realitos, on the National Mexican Railway. The greatest damage seems to have been done along the lower Nueces River. During 1895, and particu-

larly in the latter part of the season, it extended its range to a considerable extent. Toward the east it was found in moderate abundance along the valley of the Guadalupe River at Victoria, Thomaston, and Cuero. North of its old range it extended to Kenedy, Floresville, and many points in the country lying between the latter place and Cuero. A single field was found near San Antonio which contained weevils in large numbers, and in the same way a single field was found far to the east, at Wharton, in which the weevils had appeared late in the season. The exact localities where the insect was found during 1895 are indicated on the accompanying map (fig. 8).

It was feared that during 1896 there would be a further spread of the weevil; but for some reason, probably on account of the severe mid-summer drought, there was not only no spread beyond the limits of 1895, but on the contrary a shrinkage of the territory infested. The main spread in 1895 took place in the autumn, and at the outer boundaries, as at San Antonio and Wharton, the weevil was killed by the winter frosts. In 1896 the drought prevented the "make" of the top crop at many points and there was little food for the autumnal generations of the weevil, and therefore a lesser spread from the localities of successful hibernation.

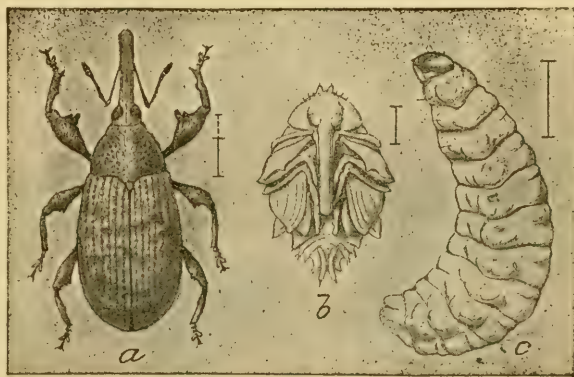


FIG. 7.—The cotton-boll weevil (*Anthonomus grandis*): a, adult beetle; b, pupa; c, larva—enlarged (from Insect Life).

NATURAL HISTORY AND HABITS.

The insect passes the winter in the weevil state. It can be found on the cotton plant until late in December, and, in fact, as long as any portion of the plant is green. It is found most abundantly in the early winter hidden between the involucre and the boll, and later it frequently works its way down into the dry and open bolls. All the specimens found by Mr. Schwarz in such situations in the late spring of 1895 were dead; but Mr. Townsend found a few living in March. The dry boll is probably not a frequently successful hibernating place.

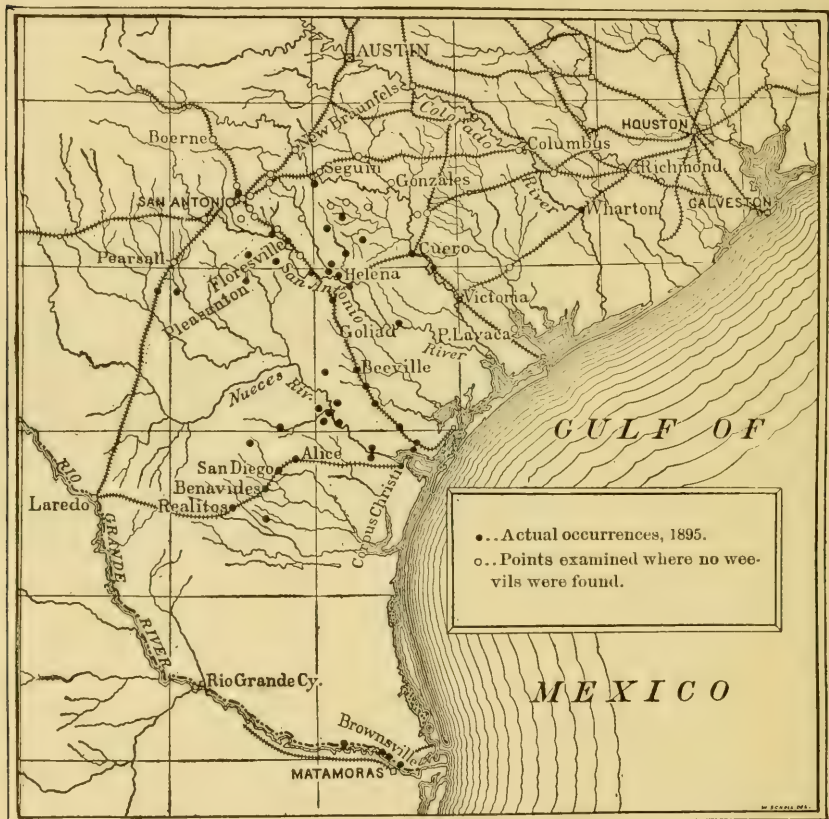


FIG. 8.—Map showing distribution of the Mexican cotton-boll weevil in 1895.

With the cutting of the plants, or with the rotting or drying of the bolls as a result of frost, the adult weevils leave the plant and seek shelter under rubbish at the surface of the ground, or among weeds and trash at the margin of the fields. Here they remain until the warm days of spring, when they fly to the first buds on such volunteer plants as may come up in the neighborhood. They feed on these and lay their eggs on the early squares, and one or perhaps two generations are developed in such situations, the number depending upon the character

of the season and the date of cotton planting. By the time the planted cotton has grown high enough to produce squares the weevils have become more numerous, and those which have developed from the generation on volunteer cotton attack the planted cotton, and through their punctures, either for feeding or egg laying, cause a wholesale shedding of the young squares. It seems to be an almost invariable rule that a square in which a weevil has laid an egg drops to the ground as a result of the work of the larva; in the square on the ground the larva reaches full growth, transforms to pupa, and issues eventually as a beetle, the time occupied in this round approximating four weeks. Later, as the bolls form, the weevils attack them also and lay their eggs in them, and the larvæ develop in the interior just as with the squares. The bolls, however, do not drop. Fig. 9, *a*, and *b*, show the larvæ in the squares, and fig. 9, *c*, shows a young boll cut open and the pupa in its customary position.

There is a constant succession of generations from early spring until frost, the weevils becoming constantly more numerous and the larvæ and pupæ as well. A single female will occupy herself with egg laying for a considerable number of days, so that there arises by July an inextricable confusion of generations, and the insect may be found in the field in all stages at the same time. The bolls, as we have just stated, do not drop as do the squares,



FIG. 9.—The cotton-boll weevil: *a*, newly hatched larva in young square; *b*, nearly full-grown larva *in situ*; *c*, pupa in young boll picked from ground (author's illustration).

but gradually become discolored, usually on one side only, and by the time the larvæ become full grown generally crack open at the tip. While in a square one usually finds but a single larva, in a full-grown boll as many as twelve have been found. In any case, however, the hatching of a single larva in a boll results in the destruction of the boll to such an extent that its fiber is useless. Where no serious frost occurs in December, the insects all, or nearly all, reach maturity and enter hibernating quarters, although larvæ have been found even in January at Sharpsburg. Whenever a heavy frost comes in this month, or before, the observations show that those insects which have not reached the beetle stage are nearly all killed. From this fact it follows that the insect will probably not prove as injurious in other portions of the cotton belt as it is in southern Texas.

It was found during the latter part of 1895 that the weevil was present

in a number of localities in which it was not known by the planters themselves to occur. It is important that every planter who lives in or near the region which we have mapped out should be able to discover the weevil as soon as it makes its appearance in his fields. Where a field is at all badly infested, the absence of bloom is an indication of the presence of the insect. In the early part of the season the weevils attack the squares first, and these wilt and drop off. A field may be in full blossom, and as soon as the insect spreads well through it hardly a blossom will be seen. This dropping alone, however, is not a sufficient indication of the weevil's presence. Squares are shed from other causes, but if a sufficient number of fallen squares are cut open the cause will be apparent. The characteristic larva of the weevil will be quite readily recognizable on comparison with the figures which we publish herewith.

As stated above, the bolls do not drop. The punctures made by the weevils in feeding, however, are comparatively characteristic, and

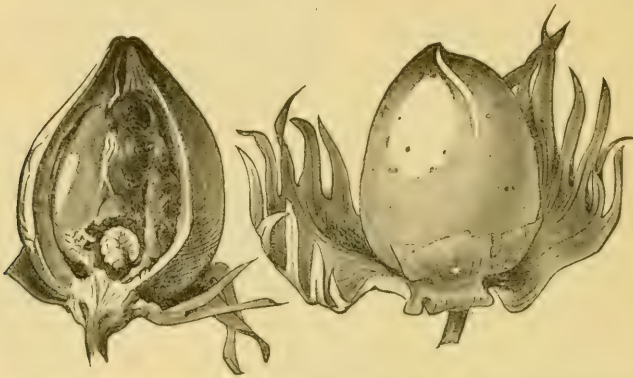


FIG. 10.—Mature boll cut open at left, showing full-grown larva; the one at the right not cut, and showing feeding punctures and oviposition marks (author's illustration).

where a boll is discolored and has begun to crack at the tip the larva or the pupa can be seen without trouble on cutting it open. Late in the season the weevils themselves will be found between the involucre and the boll, as shown in fig. 11; or in their absence the feeding marks and the yellow, granular excrement which collects in the involucre at the base of the boll are excellent indications.

PARASITES AND NATURAL ENEMIES.

It is safe to say that little assistance will be derived from the work of natural enemies and parasites upon this insect. Of the former none of any importance have been found. Several parasites, however, have been found to attack it, and in one or two localities some little good has resulted from their work. They have only been abundant, however, late in the season, after the weevil has completed its damage for the year, and at a time when a minimum of good can be accomplished

by the destruction of the larva. The majority of the weevils in a given field fail to hibernate successfully, being killed by cold weather or some other cause, so that the work of parasites at this time does not count. Careful estimates, however, show that from 15 to 20 per cent of the weevil larvae in fallen squares in November at Beeville and Kenedy were destroyed by parasites. There is a bare possibility that in the original home of the weevil (south Mexico and some Central American States, as well as certain of the West Indies) more efficacious parasites could be found. Mr. Townsend, however, while on a trip to Yucatan, was not only unable to find parasites, but captured only a single specimen of the weevil itself.

REMEDIES.

In considering the matter of remedies it should be understood at the outset that experience has shown that none of the general applications of insecticides are of the slightest value against this species as a means of protecting infested fields. The weevil in its work in growing cotton is thoroughly protected against poisons, breeding as it does within the blossoms and squares. As demonstrated by the experience of the spring of 1896, poisons may, however, be used as a means of destroying overwintered beetles on volunteer cotton. The beetles which have survived the winter collect in the early spring on the first sprouts which appear on old cotton and eat the partially expanded leaves and the tender leaf stems, and at this stage can be poisoned by the application of an arsenical to this new growth. To do this it will be necessary to thoroughly spray the growing tips, and this should be done when volunteer cotton is very small, preferably mere sprouts or bunches of leaves an inch or two in length; later on the growing parts can not be easily reached. With an ordinary knapsack pump a field may be gone over rapidly and the volunteer cotton thoroughly treated, the nozzle being directed at each growing tip. The first application should be made as soon as the volunteer sprouts, and perhaps repeated two or three times within as many weeks. As ordinarily cultivated, the number of volunteer plants is small and the time required for the thorough spraying of such plants will not be great. A strong solution should be applied, viz, 1 pound of the poison to 50 gallons of water, because no harm will be done if the volunteer plants are ultimately killed by the poison.

The practicability of this method has been demonstrated, but it has been abundantly shown that the very best system of control of the weevil is in a system of cultivation of cotton, to be later described, which will prevent all possibility of volunteer growth whatever. The poisoning and the other palliative measures relative to volunteer growths



FIG. 11.—Late-fall boll, showing how beetles hide between boll and involucre (author's illustration).

are given, therefore, merely as a means of correcting an evil which may result if the cultural system referred to has been neglected. These remarks apply, for instance, to the trap system, which we have hitherto recommended among others. This consists of attracting the earliest beetles to a few cotton plants left at convenient points and protected from winter killing by forced watering, so that they will branch out and acquire buds often in advance of volunteer cotton. From these the beetles may be collected by hand when they are attracted to them by the first warm days, or, preferably, these plants may be poisoned, as already suggested.

The fact that the spring generation develops only upon volunteer cotton has suggested the possibility that the insect will not spread beyond the region where volunteer cotton will grow in spring, but unfortunately this possibility is by no means absolutely to be relied upon. Nevertheless, the destruction of such volunteer plants as come up in cornfields and in abandoned fields which the previous year were planted to cotton, unless they be systematically poisoned, can not be too strongly recommended, for it is a matter of observation that the shade afforded by the corn or the rank-growing weeds which come up in abandoned fields is especially favorable to the development of the weevils.

While the plants are young, and where labor is as cheap as it is in south Texas, a great deal of good can be accomplished by picking and burning the fallen squares, and if this is done promptly a large number of the insects will be destroyed. It should be done at least twice, at intervals of three weeks, during the period while the plants are small. As soon as the plants begin to branch out, however, this method becomes impracticable, on account of the difficulty of finding the squares on the ground.

The idea of picking the affected bolls during the cotton picking was suggested in the writer's first published account of this insect. It was thought that the affected bolls could be so readily recognized that many thousands of the insects could be destroyed by the cotton pickers by picking these affected bolls and carrying them away in a separate receptacle to be burned. The amount of extra labor involved in this operation, however, would be very considerable, and the affected bolls in many instances are not to be recognized at a glance.

During the past year Mr. Stronball, of Beeville, has devised a machine for jarring the affected squares and blossoms from young cotton plants and collecting them at the same time. This apparatus has been given a partial demonstration the past season and seems to do fair work. It is arranged to brush the cotton from both directions vigorously, and the loosened bolls and squares are caught on receiving trays and ultimately burned or otherwise destroyed. The brushes work in opposite directions and strike the cotton plants on either side. It can be adjusted to plants of different ages.

The careful investigation of this weevil during the past two or three years by the Division of Entomology has fully demonstrated the supreme importance of the cultural method of control, to which fact we gave special prominence in our first circular on this insect. There can be no question now that in the proper system of farming cotton a practically complete remedy for the weevil exists. In the first place, it has been established beyond question that the conditions of cultivation which make volunteer growth possible also makes the continuance of the weevil inevitable. Of first importance is the early removal of the old cotton in the fall, preferably in November or earlier. This can be done by throwing out the old plants with a plow, root and all, and afterwards raking them together and burning them. This treatment should be followed, as promptly as may be, by deep plowing, say to a depth of 6 or 8 inches. This leaves the field comparatively clean of old cotton stalks, facilitates thorough cultivation the following year, and, at the same time, collects and destroys all of the weevil larvæ and pupæ in the cotton at the time, and also most of the adults. The escaping beetles will be buried by deep plowing, and will not again reach the surface. Few, if any, of them will succeed in hibernating in the absence of cotton stalks and other ordinary rubbish in which they winter. Fields treated in this way have given a practical demonstration of the usefulness of the method.

The greatest danger from the weevil is due to the presence of volunteer cotton, which means early food for the weevils in the spring and abundant means for their overwintering, and the effort made to retain volunteer and get early cotton, or the "first bale," is a very serious menace to cotton culture within the weevil district.

This cultural method, if generally practiced, will undoubtedly prove a perfect remedy for upland cotton, and will vastly reduce weevil damage in the lowlands, where the weevil is more apt to winter, perhaps in adjoining woods or roadside vegetation. The early removal of cotton by the means suggested is especially advised whenever the presence of the weevil shows that the picking of a top crop is problematical. In such instances it would be well to uproot and destroy cotton stalks in September or October, as would have been thoroughly feasible for much of the upland cotton in 1896. If this cultural method can be enforced, either by State legislation or by the cooperation and insistence on the part of landowners that their renters shall carry out the system outlined, the weevil difficulty can undoubtedly in very large measure be overcome.

In connection with the system of fall treatment of the cotton, constant and thorough cultivation of the growing crop is of considerable value, and is also what should be done to insure a good yield. With a crossbar to brush the plants many of the blossoms and squares containing weevils will be jarred to the ground and buried, together with those already on the ground, in moist soil, and a large percentage of the material will rot before the contained insects have developed.

OTHER COTTON INSECTS.

The reports of the Entomological Commission and the report by Comstock, published by this Department in 1879, treated only incidentally of the other insects which affect the cotton plant. The main endeavor in the large investigation was to cover the ground of the cotton worm; even the bollworm was considered as of minor importance. In fact, the only consideration given to the subject of the other insect enemies of this crop has been the description of a few species by Glover in several of the earlier reports of this Department, and in his copper-engraved folio entitled "Cotton insects." The writer has compiled a list of the insects found in the cotton fields and which are mentioned in the reports of Glover, in the bulletins and special reports of the Division of Entomology, in Bulletin 3 and the Fourth Report of the Entomological Commission, together with those mentioned in the notebooks of the Division of Entomology and of the United States Entomological Commission, and has added to this list the species mentioned in the monthly reports of the statistical division of this Department, those collected by Ashmead in Mississippi in the summer of 1893, those collected by Barnard in Louisiana in 1879-80, and those collected by Mally in Mississippi and Louisiana in 1890-91, together with a few collected by Banks in Louisiana in 1891.

The list as a whole comprises about 465 species. A small proportion of these, however, can be considered as injurious to the cotton plant and still smaller numbers have attracted the attention of cotton planters through their injuries to the crop. Many of them are parasitic or predaceous upon species which damage the plant to a greater or less extent, while many others are accidental visitors to the cotton fields, and might have been collected as readily in fields of corn or cowpeas in the same general locality. Some little consideration, however, may be given here to certain species which occasionally accomplish considerable damage.

CUTWORMS.

The first insect which attacks the young cotton plant in the spring is liable to be a cutworm. Soon after the young plants come up, and often after they are fairly well grown, they are liable to be cut off at the surface of the ground by one of these caterpillars, all of which have the habit of hiding beneath the surface of the ground by day and coming out to work at night. The work of these insects in general was frequently mentioned by Glover, but the species were not determined. In Riley's report as Entomologist to this Department for 1884 the subject of cutworms in cabbage fields received careful treatment, and the statement was incidentally made upon page 291 that the granulated cutworm (the larva of *Feltia annexa* Treitschke) is probably the most common of the species collectively designated by Glover as the "cotton cutworm." This species is illustrated herewith. A number of other species, how-

ever, are undoubtedly concerned in this damage. The larvæ of *Feltia malefida*, *Noctua c-nigrum*, *Agrotis ypsilon*, and *Plusia rogationis* have been found to have similar habits.

Since the discovery of the poisoned-trap system, there is no reason why land should be allowed to be infested by cutworms year after year. Dr. A. Oemler, of Wilmington Island, Georgia, the author of the excellent little book entitled "Truck farming in the South," had been for some years in the habit of scattering bunches of grass through his fields, or placing here and there turnip or cabbage leaves, and collecting from time to time the cutworms which had gathered under them. At the suggestion of Professor Riley, in 1882 or 1883, he began poisoning these vegetable traps with paris green, which saved the trouble of examining them

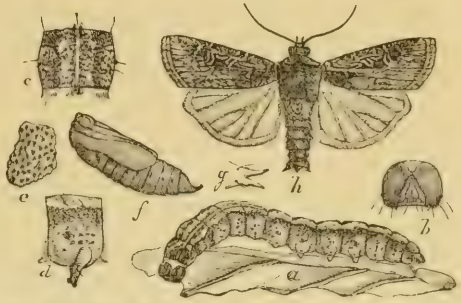


FIG. 12.—*Feltia annexa*: a, larva; f, pupa; h, moth—natural size (after Riley).

and killing the worms by hand. The method proved perfectly satisfactory, and has since been extensively used in all parts of the country. An innovation was later adopted by Prof. A. J. Cook, of Michigan, who poisoned a patch of grass with a broadcast sprayer, afterwards cutting the grass, loading it on a wagon, and pitching it with a fork in little bunches here and there through the field. Any early vegetation may be used in this way, and extensive fields can be economically rid of the worms before most crops show themselves above ground.

PLANT-LICE.

While the cotton plant is yet young and tender, the damage which plant-lice do by gathering upon the young shoots and tender leaves and curling and distorting them may be very considerable. The species engaged in this work is generally, if not always,

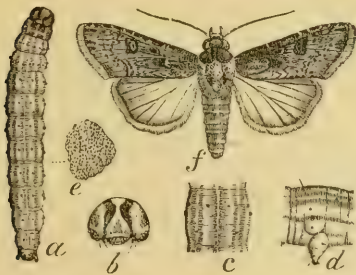


FIG. 13.—*Feltia malefida*: a, larva; f, moth—natural size (after Riley).

Aphis gossypii Glover. Recent investigations by Mr. Pergande, of this Division, have shown that this insect is identical with the species which occurs commonly through the South, and the North, too, for that matter, upon melons and cucumbers, and which was described by Ashmead as *Aphis citrulli* and by Prof. S. A. Forbes as *Aphis cucumeris*. It has very many food plants, as has been shown by Pergande, and remedial work, except upon the crop which it is proposed to protect, is practically out of the question. In other words, there is no single

alternate perennial food plant, as in the case of the hop aphid, upon which the insect may be destroyed during the earlier or later portion of the year. As the cotton plant grows larger and stronger the work of the cotton aphid becomes of no importance, partly through the hardier condition of the plant, but also through the fact that the many natural enemies of the lice increase to such numbers as nearly to annihilate them. There will seldom be, therefore, any necessity for the application of remedies; and, indeed, as nothing can be done except to spray with a dilute kerosene-soap emulsion or a resin wash, it is a question whether it will not pay the cotton grower much better to replant the damaged spots.

LEAF-FEEDING CATERPILLARS.

There are many Lepidopterous larvæ which feed upon the leaves of the cotton plant; few of them, however, are confined to the cotton plant for food. One of the species most commonly noticed, *Cacæcia rosaceana*, is known from its work as the leaf roller—a title under which another species, *Dichelia sulphureana*, may also be included. Both species are general feeders and are found in various parts of the country, the

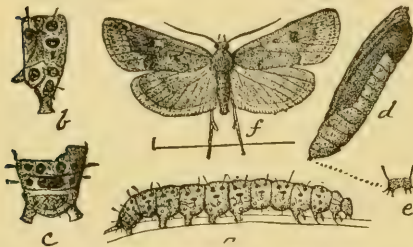


FIG. 14.—*Pyrausta nantalis*: a, larva, enlarged; b, side view of abdominal segment of same; c, dorsal view of anal segment, still more enlarged; d, pupa; f, moth, enlarged (after Riley).

former upon apple, rose, peach, cherry, birch, clover, honeysuckle, bean, strawberry, and other plants, and the latter upon clover and grass. The larvæ of the former, in addition to folding the leaves of cotton and feeding within the roll, sometimes bore into the young bolls (Mally), but this method of damage is rare.

Several of the larger Bombycids also feed in the larval state upon cotton. Among these we may mention the large royal horned caterpillar, *Citheronia regalis*, sometimes known as the "hickory horned devil," a very large green caterpillar with long recurved red horns; the large green, somewhat hairy larva of the Imperial moth (*Eacles imperialis*), and the large spiny larva of *Epantheria scribonia*, as well as the yellow-green stinging caterpillar of the Io moth (*Hyperchiria io*), and the "woolly bear" caterpillars of *Leucarcia acraea*, *Spilosoma virginica*, and *Arctia phyllira*. The last-named species seems to possess greater capabilities for damage than any of the others, and H. E. Weed has reported a case in which several acres were entirely defoliated by it about the middle of June, in Mississippi.

Two bagworms are also occasionally found feeding upon cotton leaves, constructing their cases from fragments of the leaves sewed together with silk. These are the common bagworm of the North, *Thyridopteryx ephemeraformis*, and Abbot's bagworm (*Oiketicus abbotii*), a Southern species.

Late in the fall the common grass worm, or fall army worm (larva of *Laphygma frugiperda*), ranges through the cotton fields, feeding upon volunteer grass, and occasionally ragging the leaves of the cotton plant. Two allied native species, viz, *Prodenia commelineæ* and *P. flavi-media*, also occasionally feed upon cotton leaves.

The larva of the handsome little butterfly known as *Thecla pæas* feeds upon the leaves and occasionally bores into the bolls.

The larvæ of *Acronycta obliqua* and *Anisota senatoria* have also been found by Mally engaged in this work.

In a limited section of the country, namely, in portions of Texas and the Indian Territory, the so-called garden webworm, *Pyrausta nantalis*, occasionally does some damage to the cotton crop, as it did in 1885. Feeding principally upon corn, its injury to cotton is incidental, yet it may, in the early part of the season particularly, do some little damage to this crop. Its preference for corn is noticed mainly when fields overrun with pigweed and careless weed (*Amarantus* spp.) are broken up for planting, and, in fact, these weeds seem to be its natural food. It will probably never do serious damage to cultivated crops, except where these weeds have been allowed to run wild for a season or so and are then plowed under and the land planted to some useful crop. The small green caterpillars feed upon the leaves, concealing themselves between them during the day and skeletonizing them at night.

The remedy for any or all of these leaf-feeding caterpillars, whenever one of them occasionally becomes so abundant as to threaten damage, as happened with the *Arctia phyllira* above mentioned, will be to spray with paris green, or dust it on dry, as for the cotton caterpillar.

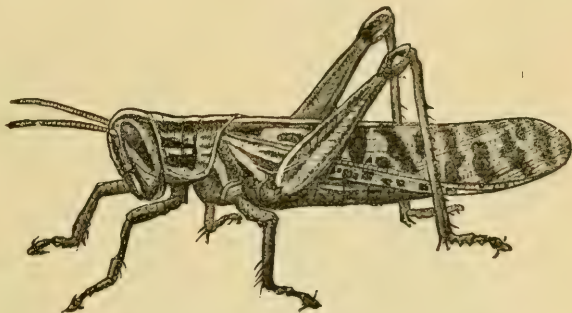


FIG. 15.—*Schistocerca americana*: adult female—natural size (from Insect Life).

OTHER INSECTS WHICH DAMAGE THE LEAVES.

Among the other insects which injure the foliage of the cotton plant, grasshoppers are the most prominent. Several species have this habit, and the list of cotton insects contains the names of fourteen which are found upon the plant. Here also the damage to cotton seems incidental; they feed by preference upon grass. The species which ordinarily cause the greatest alarm among cotton planters are the large American locust (*Schistocerca americana*) and the lubber grasshopper (*Brachystola magna*). The paris green treatment will again be effective here, but

when grasshoppers occur in considerable numbers, attracting them to a mash made of sweetened bran and arsenic will prevent leaf feeding to a great extent.

Many leaf hoppers and several leaf-feeding beetles have been found upon the cotton plant, but need not be particularly mentioned here. In many portions of Texas the leaves are frequently cut off by the so called leaf-cutting ant, *Pecodoma fervens*. One of the few practical remedies against this destructive insect, which damages fruit trees and other field crops as well as cotton, consists in tracing the ants to their nest (which is often an extremely difficult thing to do) and destroying them there by copious applications of kerosene or bisulphide of carbon. Another method, which has been practiced with some success by an intelligent Texan, is to spread a line of cyanide of potassium across the well-defined path by which the ants leave their nest; this kills very many, and deters the ants from taking the direction of the particular path thus obstructed.

INSECTS DAMAGING THE STALK.

Puncturing of the terminal portion of the stalk by plant bugs occasionally occurs, but is comparatively rare. There is but one borer in

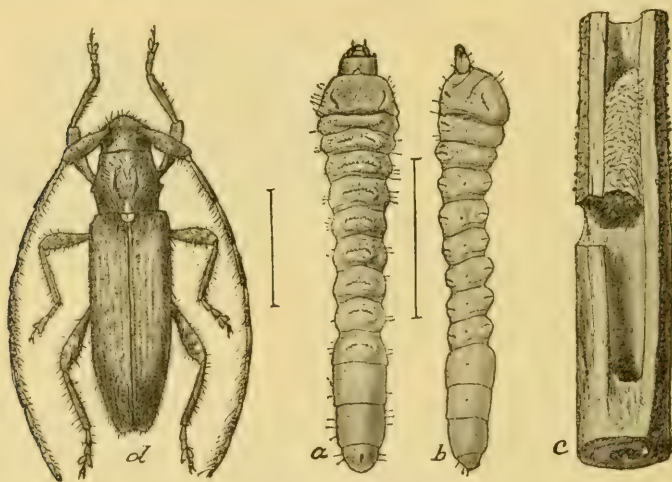


FIG. 16.—Cotton stalk borer (*Ataxia crypta*): a, larva from above; b, larva from side; c, tunneled cotton stalk showing exit hole; d, adult beetle—all enlarged except c (author's illustration).

the stalks of cotton, and that is the long-horned beetle known as *Ataxia crypta* (fig. 16). It is occasionally mistaken for an enemy to the plant, but investigation has shown that it lays its eggs upon and its larvae bore into only such stalks as have been damaged by some other cause, such as rust. It follows injury to the plant, therefore, rather than causes it.

INSECTS INJURING THE BOLL.

As in the case of the stalk borer just mentioned, numerous species of insects are found in damaged bolls which are the result, rather than the cause, of the damage. Several little Nitidulid beetles are found in

such injured bolls, and a number of other insects have been sent to the Division of Entomology of this Department from time to time with the statement that they threatened damage to the crop. Among these the larva of a little weevil, *Aræcerus fasciculatus*, deserves especial mention for the reason that it so closely resembles the larva of the Mexican cotton-boll weevil. In fact, the larvæ of both species are found living in the same boll. *Aræcerus fasciculatus* is a cosmopolitan insect living in the pods of various plants, among others in those of the coffee plant in Brazil, but is never known to attack healthy plants. The perfect weevil is also among the various insects which are mistaken by the planters for the Mexican cotton-boll weevil, but its very short and blunt beak should at once

distinguish it from the latter species. Aside from the true bollworm, several of the caterpillars found upon the plant will occasionally gnaw the bolls, but this gnawing is in general incidental to their work upon the leaves. One of these is a leaf roller, the larva of *Platynota sentana*, which attacks the forms and squares, much like the young bollworm, afterwards feeding upon the leaves. A congeneric species (*Platynota rostrana*) also bores into the young bolls. The reddish larva of a little Tineid moth belonging to a group mostly composed of leaf miners, and known as *Batrachedra rileyi*, is often found in the young bolls, and is generally believed by planters to act independently of bollworm damage. This statement, however, has not yet

been satisfactorily substantiated so far as it refers to the bolls. In the young squares, however, the active little reddish larva of this *Batrachedra* is very often found as unquestionably an original inhabitant, and it undoubtedly frequently causes quite an extensive shedding of the squares. This, however, occurs only in the spring, at a time when there is a surplus of bloom and when many squares can be spared without great reduction of the crop. Later in the season the *Batrachedra* larva is found boring in the unopened flower heads of various weeds.

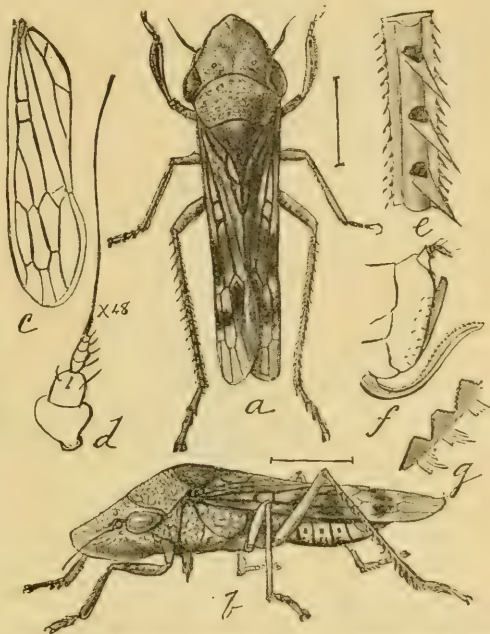


FIG. 17.—*Homalodisca coagulata*: a, adult female seen from above; b, same, side view; c, venation of fore wing, enlarged; d, antenna; e, section of hind tibia; f, female genitalia, still more enlarged; g, serrations of ovipositor, still more enlarged (from Insect Life).

There is a class of damage to the bolls which is known to planters as "sharpshooter work," which is mainly caused by the punctures of a leaf hopper known as *Homalodisca coagulata*. The insect is most abundant from the first of June on through the season. Prior to the first of June it seems to prefer the young growth and foliage of poplars and other trees which may grow in the immediate vicinity. Where sharpshooter work is prevalent in the cotton field, year after year, and the trees which harbor the insects can be found in the early part of the season, a single application of kerosene emulsion to the lower parts of such trees or scrub growth might be made to advantage in the month of May.

An insect which at one time did very considerable damage to cotton bolls, particularly those which were far advanced or had burst, is the red bug or cotton stainer, *Dysdercus suturellus*. This insect was never

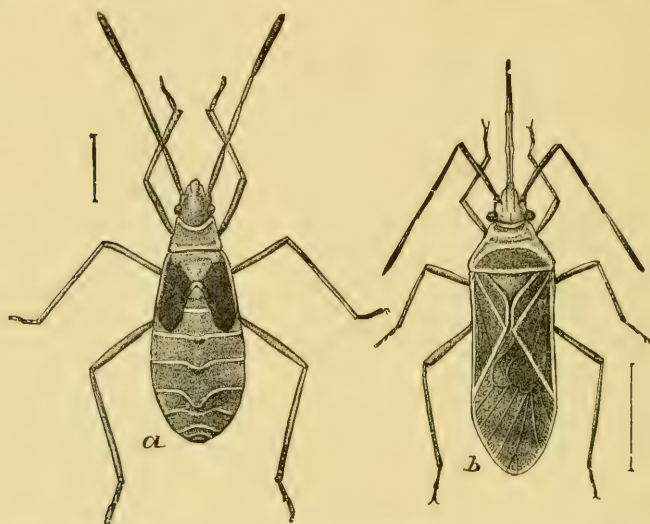


FIG. 18.—The red bug, or cotton stainer (*Dysdercus suturellus*): a, pupa; b, adult—enlarged (from *Insect Life*).

prevalent except in Florida, Georgia, and neighboring portions of South Carolina and Alabama. It is probably a West Indian species. Of late years, and more especially since cotton culture in Florida has given place to extensive orange culture, it has largely transferred its attention to the orange fruit. Earlier generations of this insect damaged the bolls by puncturing them and sucking the sap, causing them to become diminutive or abortive. Later, however, they entered open bolls, puncturing the seed and damaging the fiber by their yellowish excrement. These stains were indelible and greatly depreciated the value of the cotton in the market. The indelibility and beautiful color of the stains at one time suggested the use of the insects in making dyes. Experiments showed that the entire substance of the insect could be

converted into a rich orange-yellow dye, which could be readily fixed upon woolens or silks by the alum mordant liquor, and that an ochreous yellow lake could be made from them by precipitating the coloring matter with gelatinous alumina. There has been, however, no commercial adoption of the results of these experiments.

The best remedy against this species is suggested by the fact that in winter it will collect in numbers on piles of cotton seed, which can then be used as traps and the insects destroyed by the application of hot water.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number and title of each. Copies will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

No. 16. Leguminous Plants. No. 22. The Feeding of Farm Animals. No. 24. Hog Cholera and Swine Plague. No. 25. Peanuts: Culture and Uses. No. 27. Flax for Seed and Fiber. No. 28. Weeds: And How to Kill Them. No. 29. Souring and Other Changes in Milk. No. 30. Grape Diseases on the Pacific Coast. No. 31. Alfalfa, or Lucern. No. 32. Silos and Silage. No. 33. Peach Growing for Market. No. 34. Meats: Composition and Cooking. No. 35. Potato Culture. No. 36. Cotton Seed and Its Products. No. 37. Kafir Corn: Culture and Uses. No. 38. Spraying for Fruit Diseases. No. 39. Onion Culture. No. 41. Fowls: Care and Feeding. No. 42. Facts About Milk. No. 43. Sewage Disposal on the Farm. No. 44. Commercial Fertilizers. No. 45. Insects Injurious to Stored Grain. No. 46. Irrigation in Humid Climates. No. 47. Insects Affecting the Cotton Plant. No. 48. The Manuring of Cotton. No. 49. Sheep Feeding. No. 50. Sorghum as a Forage Crop. No. 51. Standard Varieties of Chickens. No. 52. The Sugar Beet. No. 53. 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No. 86. Thirty Poisonous Plants. No. 87. Experiment Station Work—VIII. No. 88. Alkali Lands. No. 89. Cowpeas. No. 91. Potato Diseases and Treatment. No. 92. Experiment Station Work—IX. No. 93. Sugar as Food. No. 94. The Vegetable Garden. No. 95. Good Roads for Farmers. No. 96. Raising Sheep for Mutton. No. 97. Experiment Station Work—X. No. 98. Suggestions to Southern Farmers. No. 99. Insect Enemies of Shade Trees. No. 100. Hog Raising in the South. No. 101. Millets. No. 102. Southern Forage Plants. No. 103. Experiment Station Work—XI. No. 104. Notes on Frost. No. 105. Experiment Station Work—XII. No. 106. Breeds of Dairy Cattle. No. 107. Experiment Station Work—XIII. No. 108. Saltbushes. No. 109. Farmers' Reading Courses. No. 110. Rice Culture in the United States. No. 111. Farmers' Interest in Good Seed. No. 112. Bread and Bread Making. No. 113. The Apple and How to Grow It. No. 114. Experiment Station Work—XIV. No. 115. Hop Culture in California. No. 116. 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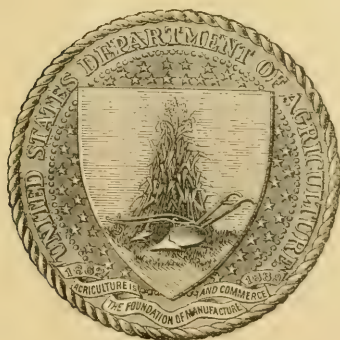
FARMERS' BULLETIN No. 59.

BEE KEEPING.

BY

FRANK BENTON, M. S.,

ASSISTANT ENTOMOLOGIST.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., July 25, 1897.

SIR: Frequent inquiries from correspondents of the Department of Agriculture for information on matters pertaining to the culture of bees, and particularly as to the conditions under which one may reasonably expect to meet with success in this pursuit, have led to the preparation of this bulletin. Though it has been designed by the author primarily to answer a few of the specific questions which are most likely to present themselves to the mind of the inquirer wholly unfamiliar with the subject, the aim has been also to introduce in the treatment of the various topics information which it is hoped will lead many of longer experience into more successful methods than they have yet practiced.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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BEE KEEPING.

LOCATIONS SUITED TO THE KEEPING OF BEES.

It may be safely said that any place where farming, gardening, or fruit raising can be successfully followed is adapted to the profitable keeping of bees—in a limited way at least, if not extensively. Many of these localities will support extensive apiaries. In addition to this there are, within the borders of the United States, thousands of good locations for the apiarist—forest, prairie, swamp, and mountain regions—where agriculture has as yet not gained a foothold, either because of remoteness from markets or the uninviting character of soil or climate. This pursuit may also be followed in or near towns and, to a limited extent, in large cities. It even happens in some instances that bees in cities or towns find more abundant pasturage than in country locations which are considered fair.

The city of Washington is an example of this, bees located here doing better during the spring and summer months than those in the surrounding country, owing to the bee pasturage found in the numerous gardens and parks and the nectar-yielding shade trees along the streets. This is due mainly to the fact that the linden, or basswood, which is rarely seen in the country about Washington, has been planted extensively in the parks and for miles on both sides of many of the streets and avenues of the city.¹ Another source in the city not found extensively in the country adjacent is melilot, Bokhara or sweet clover (*Melilotus alba*), which has crept into vacant lots and neglected corners, and spreads about its agreeable perfume to the delight of all city dwellers, whether human or insect. The writer has practiced with profit the transportation of nearly a hundred colonies from a country apiary 10 miles distant to Washington for the linden and sweet-clover yield. He has also seen a prosperous apiary kept on the roof of a business house in the heart of New York City, and on several occasions has visited another apiary of 30 to 40 colonies, which a skillful apiarist had located on the roof of his store in the business portion of Cincinnati, Ohio, and from which 30 to 40 pounds of honey per colony were usually obtained each year.

¹Several species of lindens are included in these plantings, but none yields more than our common American linden, or basswood (*Tilia americana*).

Another apiary personally inspected was located directly on the sand banks forming the eastern shore of Lake Michigan. These bees were, of course, unable to forage westward from the apiary, hence had but half "a field." The soil of the area over which the bees ranged was a light sand, unproductive for most crops, and the region was little developed agriculturally, most of the honey coming from forest trees and from shrubs and wild plants growing in old burnings and windfalls, yet 25 to 30 pounds of excellent honey per colony was the usual surplus obtained. At one time the writer had an apiary in the city of Detroit, Mich., where the wide river on one side cut off nearly half of the pasturage, yet the bees did well. And again for several years he had an apiary containing from 100 to 200 colonies of bees on a very sterile coast of the Island of Cyprus, and another nearly as large located but a few rods from the seashore on a rocky point of Syria. Both of these apiaries were devoted in the main to queen rearing, yet the yield of honey was not an unimportant item, especially in the Syrian apiary, while in the Cyprus apiary some honey was frequently taken, and it was rarely necessary to feed the bees for stores. In the latter case about one-fourth of the range was cut off by the sea, the bees being located at the head of an open bay and a short distance from the shore, while the location of the Syrian apiary prevented the bees from securing half of the usual range, hence their greater prosperity was due to the nature and quantity of the pasturage of their limited range.

It is evident, therefore, that no one similarly located need be deterred from keeping bees, provided the nectar-yielding trees and plants of the half range are of the right sort and abundant. Moreover, regions so rough and sterile or so swampy as to give no encouragement to the agriculturist, or even to the stock raiser, will often yield a good income to the bee keeper, insignificant and apparently worthless herbs and shrubs furnishing forage for the bees. The ability of the bees to range over areas inaccessible to other farm stock and to draw their sustenance from dense forests when the timber is of the right kind, and the freedom which, because of their nature, must be accorded them to pasture on whatever natural sources are within their range of 3 or 4 miles, must be taken into account in estimating the possibilities of a locality. It will be found that very few localities exist in our country where at least a few colonies of bees may not be kept. Whether a large number might be profitably kept in a given locality can only be decided by a careful examination as to the honey-producing flora within range of the apiary. (See pages 5 and 15-18).

THE RETURNS TO BE EXPECTED FROM AN APIARY.

Although apiculture is extremely fascinating to most people who have a taste for the study of nature, requiring, as it does, out-of-door life, with enough exercise to be of benefit to one whose main occupation is sedentary, the income to be derived from it when rightly followed is

a consideration which generally has some weight and is often the chief factor in leading one to undertake the care of bees. Certainly, where large apiaries are planned, the prime object is the material profit, for they require much hard labor and great watchfulness, and the performance of the work at stated times is imperative, so that in this case there is less opportunity than where but a few colonies are kept to make a leisurely study of the natural history and habits of these interesting insects, because—unless the keeper is willing to forego a considerable portion of his profits—his time must necessarily be almost wholly taken up in attending to the most apparent wants of his charges.

One very naturally supposes that the return from a single hive, or several of them, in a given locality, may be taken as a fair index of what may be expected each season. Such return, if considered average, may serve as a basis on which to reckon, but as so many conditions influence it great differences in actual results will be found to occur in successive seasons. Apiculture, like all other branches of agriculture, depends largely upon the natural resources of the location, and the favorableness or unfavorableness of any particular season, no matter how skillful the management, may make great differences in the year's return. The knowledge, skill, industry, and promptness of the one who undertakes the care of the apiary have likewise much to do with the return. Furthermore, profits are of course largely affected by the nature and proximity of the markets.

A moderate estimate for a fairly good locality would be 30 to 35 pounds of extracted honey or 20 pounds of comb honey per colony. This presupposes good wintering and an average season. When two or more of the important honey-yielding plants are present in abundance and are fairly supplemented by minor miscellaneous honey plants the locality may be considered excellent, and an expectation of realizing more than the yield mentioned above may be entertained. With extracted honey of good quality at its present wholesale price of 6 to 7 cents per pound and comb honey at 12 to 13 cents, each hive should under favorable circumstances give a gross annual return of \$2.50 to \$3. From this about one-third is to be deducted to cover expenses other than the item of labor. These will include the purchase of comb foundation and sections, repairs, eventual replacing of hives and implements, and the interest on the capital invested. By locating in some section particularly favorable to apiculture—that is, near large linden forests, with clover fields within range, supplemented by buckwheat; or in a section where alfalfa is raised for seed; where mesquite, California sages, and wild buckwheat abound; where mangrove, palmettoes, and titi; or where sourwood, tuliptree, and asters are plentiful—the net profits here indicated may frequently be doubled or trebled.

But these favored locations, like all others, are also subject to reverses—the result of drouths, great wet, freezes which kill back the bee pasturage, etc., and though some years the profits are so much

larger than those named above as to lend a very roseate hue to the outlook for the accumulation of wealth on the part of anyone who can possess himself of a hundred or two colonies of bees, the beginner will do well to proceed cautiously, bearing in mind that much experience is necessary to enable him to turn to the best account seasons below the average, while during poor seasons it will take considerable understanding of the subject, energetic action, and some sacrifice to tide over, without disaster, or at least without such great discouragement as to cause neglect and loss of faith in the business. On the whole, there should be expected from the raising of bees for any purpose whatever only fair pay for one's time, good interest on the money invested, and a sufficient margin to cover contingencies. With no greater expectations than this from it, and where intelligence directs the work, apiculture will be found, in the long run, to rank among the best and safest of rural industries.

ANYONE WHO DESIRES TO DO SO CAN LEARN TO MANIPULATE BEES.

Any person with fairly steady nerves and some patience and courage can easily learn to control and manipulate bees. There are, it is true, a few exceptional individuals whose systems are particularly susceptible to the poison injected by the bee, so much so that serious effects follow a single sting. Such cases are, however, very rare. In most instances where care is not taken to avoid all stings the system eventually becomes accustomed to the poison, so that beyond momentary pain a sting causes no inconvenience.

To a certain extent the belief exists that bees have, without apparent cause, a violent dislike for some people, while others, without any effort, are received into their favor. The latter part of this proposition has a better foundation than the first part, for it is the actions, rather than any peculiarity of the individual himself, that anger the bees.

Bees prefer, of course, not to be disturbed, hence they usually keep guards on the lookout for intruders. When visitors approach the hives these guards are very apt to fly toward them as if to inquire whether harm is intended or not, and should the visitor not inspire them with fear by using smoke or some similar means, but should himself show fear and nervousness, he will be very likely to arouse their suspicions still further, or even to anger them should he strike at them or endeavor to dodge their approach. Indeed, one not accustomed to the notes of bees is very likely, unconsciously, to dodge his head about when a worker buzzes uncomfortably close to his face. It may be a movement of but an inch or two, but perhaps a quick jerk, and being noticed by the suspicious guard is resented; a sting follows, and yet the recipient declares that he did nothing to cause the attack, but that bees merely hate him and always sting him when he approaches them. On the other hand, an equally unprotected person who moves about with deliberation may generally, under the same circumstances, be let off without

receiving a sting. It is in this case not so much what he does as what he does not do.

It is not to be understood that bees will always refrain from stinging if one remains somewhat passive in the vicinity of their hives, for the fact is that at some seasons common black bees and crosses having blood of this race fly some distance to attack passers-by, or even, without just provocation and with but slight warning, to plant a sting in the face of one who is standing near the apiary. But as the avoidance of such unpleasant occurrences depends largely upon the kind of bees kept, and, to a certain extent, upon an acquaintance with a few facts with which anyone of intelligence may easily familiarize himself, and the observance of certain precautions which are quite simple and after a little practice will become easy, and as the opening and manipulation of hives in securing honey, etc., is equally simple and attended with no greater risks, it is safe to say that almost anyone can, with perseverance and the exercise of due caution, learn to manipulate bees with perfect freedom and without serious risk of being stung.

HOW TO AVOID STINGS.

First, by having gentle bees. If no other point of superiority over the common brown, or black, bee than that of gentleness could be fairly claimed for some of the races introduced, and some of the strains developed in recent years, it would still be worth while to get them on this account alone. When the fact of superiority in several other important points is considered also, there should be no further question as to the advisability of procuring them in preference to the common variety. The beginner is advised never to think of doing otherwise. No one likes stings, and even the veteran who affects insensibility to the wrath of his charges will find his interest and pleasure in them much increased by replacing blacks and their crosses with better varieties. Nor is this merely to gratify a fancy or for convenience alone. If, by reason of the stinging qualities of the bees kept, an examination for the purpose of ascertaining the condition of a colony of bees becomes a disagreeable task to the one who cares for the apiary, little things necessary to the welfare of the colonies will be postponed or omitted altogether and the apiary will soon present a neglected appearance, and the actual profits will be affected. As a race, Carniolans are the gentlest; some strains of Italians equal in this respect average Carniolans, but the race native to Italy is by no means as gentle as that found in Carniola. The beginner need not hesitate, however, to undertake to manipulate pure Italians.

Crossing well-established breeds produces bees which vary greatly in temper, especially in the first few generations. Only careful selection continued for some time will so fix the desirable traits as to result in their reproduction with a fair degree of certainty in the offspring. Bees having the blood of blacks and Italians are nearly always quite vicious

in the case of the first cross, and are even harder to subdue with smoke than are pure blacks. Other races need not be considered here as they are adapted to special purposes, and the skill of the bee master, the conditions of climate, flora, etc., and the particular line of production to be followed, should decide whether their introduction is advisable or not.¹

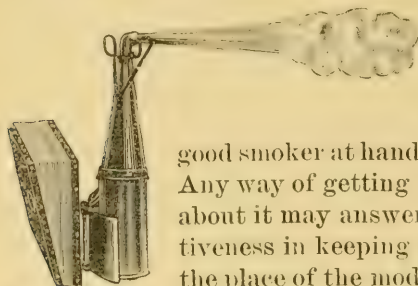


FIG. 1.—The Bingham bee smoker.

The second essential to enable one to avoid stings is to have a good smoker at hand whenever the bees are to be handled. Any way of getting smoke of any kind into the hive and about it may answer the purpose, but for ease and effectiveness in keeping bees under control nothing will take the place of the modern bellows smoker (fig. 1). A good one lasts years, and its cost is so slight (\$1 to \$1.25 for the medium sizes) that the expenditure may be considered one of the wisest that can be made in fitting up an apiary.

A veil (fig. 2), made of black bobinet or Brussels net, to draw over the hat, and a pair of gloves, preferably of rubber, may be used at first. But whoever has fairly peaceable bees and learns even a little about their ways will soon discard the gloves, unless, indeed, he be exceedingly timid, or one of those to whom a bee sting would be a dreadful affliction. The veil can be safely dispensed with if the gentlest bees are kept.

Simple and convenient hives, employing the Langstroth principle, and with stories and frames interchangeable and so constructed as to reduce propolization to a minimum and to insure straight combs, will much facilitate the avoidance of stings.

The use of the bee escape (fig. 3) in removing surplus honey greatly reduces the risk of being stung during this operation, for it saves much manipulation of combs and shaking and brushing of bees. This useful device is fitted into a slot made in a board the same size as the top of the hive, and the whole, when slipped in between the brood apartment and an upper story or super will permit all of the workers above to go down into the lower story but not to return to the top one, so that in one night it is



FIG. 2.—Bee veil.

¹For a fuller discussion of this subject, see "The Honey Bee: A Manual of Instruction in Apiculture," by Frank Benton, M. S., Bulletin No. 1, new series, Division of Entomology, U. S. Dept. of Agriculture, 1896, Chap. I, pp. 11-18.

possible to free entirely a set of combs from bees without any manipulation of the combs, and without smoking, shaking, or brushing the bees.

Lastly, reasonable care in manipulation and a suitable system of management, which, of course, implies the doing of work in proper season, will, with the observance of the foregoing points, make the risk of stings exceedingly slight. Indeed, intelligent attention to the most important of the points mentioned above, with extra gentleness and moderation in manipulation, will enable anyone who so desires to avoid all stings.

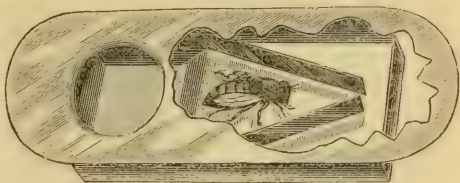


FIG. 3.—The Porter spring bee escape.

WHAT HIVE TO ADOPT.

The suspended Langstroth frame is used more than any other frame among English speaking bee keepers. It is safe to say that in the United States 500 hives are made and used which are essentially Lang-

stroth in principle to one frame hive of any other kind whatever. In the British Islands, Australia, and New Zealand, the proportion of frames on the Langstroth principle in use is probably even greater, scarcely any other frame hives being employed.

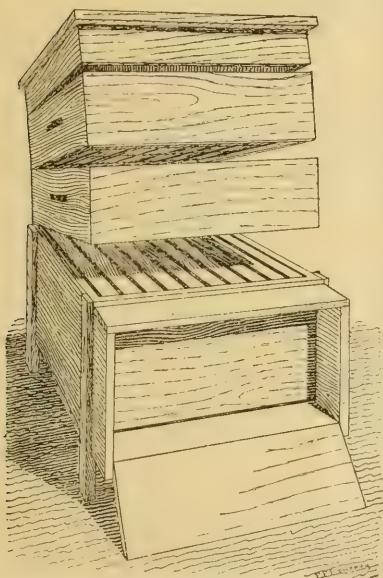


FIG. 4.—Langstroth hive with two half-depth supers for surplus honey.

The success of American bee culture in the last twenty years was first attributed by European bee keepers to the honey-producing power of the country; but the most intelligent apiarists who have tried the American methods with the Langstroth hive now recognize that success is principally due to the manipulations that it permits. ("The Hive and Honey Bee," revised by Chas. Dadant & Son, 1888, page 145.)

We can predict, and without any fear of mistake, that the principles on which the Langstroth hive is based will be admitted sooner or later by the most progressive bee keepers of the world. ("Revue Internationale d'Apiculture" (Switzerland), September, 1885, edited by Edouard Bertrand.)

There being no patent on the Langstroth hive, and accurately made hives being obtainable at moderate prices from hive factories in various parts of the country, it is taken for granted that the enterprising beginner will adopt a simple form embodying this principle—the loose-fitting, suspended comb frame—as its main feature. The hive should not only be substantially built, but should have accurate bee spaces and

a close-fitting, rain-proof cover or roof. Factory-made hives, as a rule, best meet these requirements, as both lock joints and half corners can only be made to advantage by machinery, and the expert hive builder

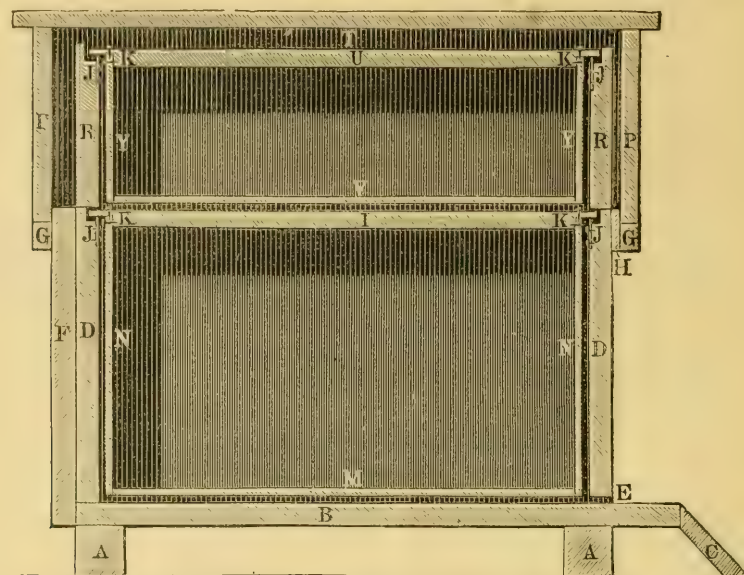


FIG. 5.—The Langstroth hive—Dadant-Quinby form—cross section showing construction.

understands, of course, the absolute necessity of great accuracy in bee spaces, as well as the great desirability of good material and workmanship (figs. 4, 5, and 11). Provision should also be made for winter protection. (See pages 23-29.)

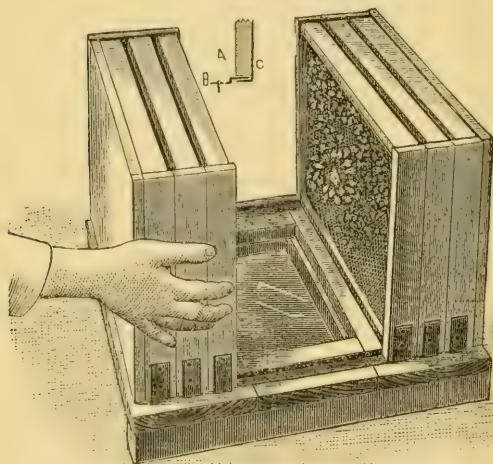


FIG. 6.—Quinby closed-end frames.

For comb honey, hives permitting the insertion in the brood apartment of any number of frames up to eight, or frequently up to ten, are most in use. In securing extracted honey, those with ten to twelve frames in each story are preferable, and as

many stories, one above the other, are employed as the strength of the colony and a given harvest may require. A construction, therefore, which readily admits of expansion and of contraction, as occasion demands, is desirable.

Mention should be made of a hive of quite different construction, a prominent feature of which is this ease of contraction and expansion. It is the last hive which the late M. Quinby gave to the public—the Quinby closed-end frame hive (fig. 6). This hive is used with great success by certain American bee keepers of long experience and whose apiaries are among the largest in the world.

MANAGEMENT IN SWARMING.

When a swarm is seen issuing or in the air, the best thing to do is, in general, simply to wait a bit. The weather is usually rather warm then, and rushing about to get tin pans, dinner gongs, spraying outfits, etc., aside from its disagreeableness, may get one so excited and into such a perspiration as to unfit him to do with the bees that which is likely to be necessary a few minutes later. They will probably gather in a clump on a tree or bush near the apiary, and however formidable getting them into the hive may at first seem, nothing will be simpler than shaking them into their new hive, or into a basket or box, from which they may be poured in front of the hive, just as one would pour out a measure of wheat or beans. If any stick to the basket or box, invert it and give a sharp thump with one edge against the ground. If the hive has been standing in the shade so that the boards composing it are not heated, if it be now well shaded and plenty of ventilation be given above and below, the bees are almost certain to take possession at once and begin work actively.

The securing of swarms can be made, however, even simpler than this by having the colonies placed several feet apart on a smooth lawn or dooryard and clipping one wing of each laying queen so as to prevent her flying. The prime or first swarm from each hive is accompanied by the old queen, and if she be clipped she will of course fall from the alighting board to the ground and may be secured in a cage. The bees will circle about a few times and return. Meanwhile the only thing for the attendant to do is to replace the parent colony by an empty hive. The returning bees will enter the latter and the queen may be allowed to go in with them, the cage being placed with its open end directly against the entrance to insure this. The swarm is thus made to hive itself. The parent colony removed to a new stand a rod or more away will rarely give a second swarm. But to make certain all queen cells except one may be cut out any time within a few days after the issuance of the first swarm. Each afterswarm (second, third, etc.), it should be borne in mind, is accompanied by one or more unimpregnated queens, and these must not be clipped until they have flown out and mated. The regular deposition of eggs in worker cells may nearly always be regarded as a safe sign that mating has taken place. Eggs will usually be found in such cells within the first ten days of the queen's life. Afterswarms may remain in the air, circling about for some time, and they frequently cluster high—a good reason, in addition to the more

important fact that their issuance is not consistent with the production of the most surplus honey, for the prevention of all after-swarming.

Where an increase of colonies is desired, and in case no one can be near the apiary to care for natural swarms with clipped queens, some one of the artificial methods of forming new colonies may be advantageously employed. Natural swarming is, however, to be preferred to a poor system of artificial increase. And no matter which of the artificial methods be adopted, it should be cautiously followed, lest, unfavorable weather appearing suddenly, considerable labor and expense be incurred to prevent disastrous results. It is also of prime importance not to weaken materially the gathering powers of strong colonies just at the opening of the harvest or during its progress; hence, whatever division takes place then must leave the field force—the gatherers, in one mass and in normal condition for work, that is, not discouraged by being queenless, and not overburdened by having brood without a sufficient number of nurse bees to care for it.

A plan which fulfills these conditions is the following: From a populous colony a comb or two with adhering bees and the queen may be taken and placed in a new hive, which, when other frames with starters have been added, is then to be put on the stand of the populous colony from which the combs were taken. The removed colony is to be taken a rod or more from its old stand, so that the flight bees returning from the field will enter the newly established colony. The old colony may be given a laying queen or a mature queen cell a day or two later. This finishes the work in a short time. A better plan, though not so quickly completed, is to take from the populous colony only enough bees and combs to make a fair nucleus on a new stand. A queen is easily and safely introduced into this nucleus, or a queen cell is readily accepted a day or two later. As soon as the young queen has begun egg laying, combs of emerging brood may be added from time to time. These may be obtained from any populous colonies whose tendency to swarm it is desirable to check, the bees adhering to them when they are removed being in all instances brushed back into their own hive. With fair pasturage the nucleus will soon be able to build combs and may be given frames of comb foundation, or, if the queen be of the current year's raising, frames with narrow strips of foundation as guides may be inserted, since all combs constructed by the nucleus will be composed of worker cells.

PREVENTION OF SWARMING.

Under the conditions most frequently occurring, however—that is, where it is not practicable to be present at all times during the swarming season, or where the desired number of colonies has been attained—a system of management is advisable which in general contemplates the prevention, in so far as possible, of the issuance of swarms without at the same time interfering with honey storing. The following

paragraphs on this subject are taken from the Department publication "The Honey Bee," cited on p. 8:

The most commonly practiced and easily applied preventive measure is that of giving abundant room for storage of honey. This to be effective should be given early in the season, before the bees get fairly into the swarming notion, and the honey should be removed frequently, unless additional empty combs can be given in the case of colonies managed for extracted honey, while those storing in sections should be given additional supers before those already on are completed. With colonies run for comb honey it is not so easy to keep down swarming as in those run for extracted honey and kept supplied with empty comb. Free ventilation and shading of the hives as soon as warm days come will also tend toward prevention. Opening the hives once or twice weekly and destroying all queen cells that have been commenced will check swarming for a time in many instances, and is a plan which seems very thorough and the most plausible of any to beginners. But sometimes swarms issue without waiting to form cells; it is also very difficult to find all cells without shaking the bees from each comb in succession, an operation which, besides consuming much time, is very laborious when supers have to be removed, and

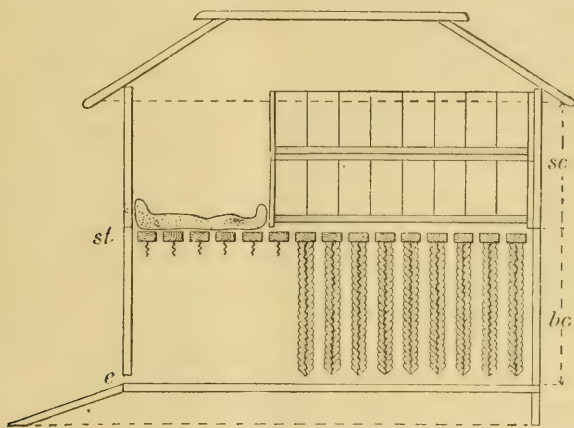


FIG. 7.—The Simmins non-swarming system—single-story hive with supers: *bc*, brood chamber; *sc*, supers; *st*, starters of foundation; *e*, entrance.

greatly disturbs the labors of the bees. If but one cell is overlooked the colony will still swarm. The plan therefore leaves at best much to be desired, and is in general not worth the effort it costs and can not be depended on.

Dequeening.—The removal of a queen at the opening of the swarming season interferes, of course, with the plans of the bees, and they will then delay swarming until they get a young queen. Then if the bee keeper destroys all queen cells before the tenth day, swarming will again be checked. But to prevent swarming by keeping colonies queenless longer than a few days at most is to attain a certain desired result at a disproportionate cost, for the bees will not store diligently when first made queenless, and the whole yield of honey, especially if the flow is extended over some time, or other yields come later in the season, is likely or even nearly sure to be less from such colonies, while the interruption to brood rearing may decimate the colony and prove very disastrous to it. The plan is therefore not to be commended.

Requeening.—Quite the opposite of this, and more efficacious in the prevention of swarming, is the practice of replacing the old queen early in the season with a young one of the same season's raising, produced perhaps in the South before it is possible to rear queens in the North. Such queens are not likely to swarm during

the first season, and, as they are vigorous layers, the hive will be well populated at all times and thus ready for any harvest. This is important, inasmuch as a flow of honey may come unexpectedly from some plant ordinarily not counted upon, and also since the conditions essential to the development of the various honey-yielding plants differ greatly, their time and succession of honey yield will also differ with the season the same as the quantity may vary. Young queens are also safest to head the colonies for the winter. The plan is conducive to the highest prosperity of the colonies, and is consistent with the securing of the largest average yield of honey, since, besides giving them vigorous layers, it generally keeps the population together in powerful colonies. It is therefore to be commended on all accounts as being in line with the most progressive management, without at the same time interfering with the application of other preventive measures.

Space near entrances.—Arranging frames with starters or combs merely begun

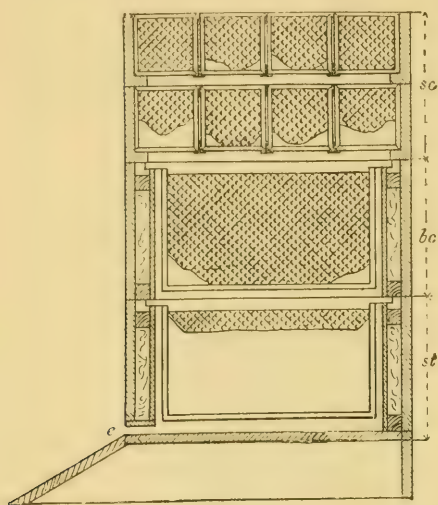


FIG. 8.—The Simmins non-swarming system—double story hive with supers: *bc*, brood chamber; *sc*, supers; *st*, chamber with starters or comb foundation; *e*, entrance.

between the brood nest and the flight hole of the hive while the bees are given storing space above or back of the brood nest (figs. 7 and 8) is a plan strongly recommended by Mr. Samuel Simmins, of England, and which has come to be known as "the Simmins non-swarming method," some features of it and the combination into a well-defined method having been original with him. It is an excellent preventive measure, though not invariably successful, even when the distinctive features brought forward prominently by Mr. Simmins—empty space between the brood combs and entrance, together with the employment of drawn combs in the supers—are supplemented by other measures already mentioned; but when, in addition to the space between the brood and the flight hole, the precaution be taken to get supers on in time, to ventilate the hive well, and to keep queens not over two years old, swarming will be very

limited. If to these precautions be added that of substituting for the old queens young ones of the current season's raising, before swarming has begun, practical immunity from swarming is generally insured.

Selection in breeding.—Some races of bees show greater inclination than others toward swarming, and the same difference can be noted between individual colonies of a given race; therefore, whatever methods be adopted to prevent or limit increase, no doubt the constant selection of those queens to breed from whose workers show the least tendency toward swarming would in time greatly reduce this disposition. Indeed, it is perfectly consistent to believe that persistent effort, coupled with rigid and intelligent selection, will eventually result in a strain of bees quite as much entitled to be termed non-swarming as certain breeds of fowls which have been produced by artificial selection are to be called non-sitters. These terms are of course only relative, being merely indicative of the possession of a certain disposition in a less degree than that shown by others of the same species. It might never be possible to change the nature of our honey bees so completely that they would never swarm under any circumstances, and even if possible it would take a long period, so strongly implanted seems this instinct. But to modify it is within the reach of any intelligent breeder who will persistently make the effort.

Such work should be undertaken in experimental apiaries where its continuance when a single point has been gained will not be affected by the changes of individual fortunes.

SPECIAL CROPS FOR HONEY ALONE NOT PROFITABLE.

With a small apiary planting for honey alone certainly can not be made profitable. Small plats of honey-producing plants are valuable mainly because they afford an opportunity of observing when and under what circumstances the bees work on certain blossoms, and for the purpose of determining what might be depended upon to fill a gap in the honey resources of a given locality whenever the size of the apiary might make this a consideration of some importance. Even with a large apiary probably no case exists in which, in the present condition of the subject, planting for honey alone would prove profitable. But when selecting crops for cultivation for other purposes, or shrubs and trees for planting, the bee keeper should of course choose such as will also furnish honey at a time when pasturage for his bees would otherwise be wanting.

As complete a list as possible should be made of the plants and trees visited by honey bees, and notes should be added as to period of blossoming, importance of yield, whether honey or pollen or both of these are collected, quality of the product, etc. If gaps occur during which no natural forage abounds for the bees, some crop can usually be selected which will fill the interval, and, while supplying a continuous succession of honey-yielding blossoms for the bees, will give in addition a yield of fruit, grain, or forage from the same land. The novice is warned, however, not to expect too much from a small area. He must remember that as the bees commonly go $2\frac{1}{2}$ to 3 miles in all directions from the apiary they thus range over an area of 12,000 to 18,000 acres, and if but 1 square foot in 100 produces a honey-yielding plant they still have 120 to 180 acres of pasturage, and quite likely the equivalent of 30 to 40 acres may be in bloom at one time within range of the bees. A few acres more or less at such a time will therefore not make a great deal of difference.

But if coming between the principal crops—especially if the bees, as is often the case, would otherwise have no pasturage at all—the area provided for them may be of greater relative importance than the larger area of natural pasturage; for it frequently occurs that the smaller part only of the honey produced by the field over which the bees of an apiary range can be collected by them before it is washed out by rains or the liquid portion is evaporated and the blossoms withered, while a smaller area may be more assiduously visited, and, the nectar being gathered as fast as secreted, a greater yield per acre may result.

It is further of some importance to fill in such a gap with something to keep the bees busy, instead of letting them spend their time trying

to rod each other; and, what is probably even more important, the pasturage thus furnished will keep up brood rearing and comb building and assist materially in preparing the colonies for the succeeding honey flow.

There are many plants and trees of economic value, in addition to their production of honey, which may be utilized in one portion or another of the United States in the manner indicated. Adaptability to climate and soil, the periods of honey dearth to be filled in, markets for the crop produced, etc., must all come in to influence the choice. The following list includes the more important plants of economic value in this country which are good honey and pollen yielders. Most of those named are adapted to a considerable portion of the Union. Except in the case of plants restricted to the South, the dates given are applicable, in the main, to middle latitudes.

ECONOMIC PLANTS AND TREES FOR CULTIVATION FOR HONEY AND POLLEN.

Filbert bushes, useful for wind-breaks and for their nuts, yield pollen in February and March.

Rape can be grown successfully in the North for pasturage, for green manuring, or for seed, and when permitted to blossom yields considerable pollen and honey. Winter varieties are sown late in the summer or early in the autumn, and blossom in April or May following. This early yield forms an excellent stimulus to brood rearing. Summer or bird rape, grown chiefly for its seed, blossoms about a month after sowing. It does best during the cooler months of the growing season.

Fruit blossoms—apricot, peach, pear, plum, cherry, apple, currant, and gooseberry—yield pollen and honey in abundance during April or May; strawberry and blackberry are sometimes visited freely by bees, but are generally far less important than the others mentioned. Colonies that have wintered well often gather during apple bloom 12 to 15 pounds of surplus honey of fine quality. The raspberry secretes a large amount of nectar of superb quality, and coming in May or June, thus later than the other fruit blossoms and when the colonies are stronger and the weather is more settled, full advantage can nearly always be taken of this yield. Grape and persimmon blossom also in June; the latter is an excellent source. In subtropical portions of the country orange and lemon trees yield fine honey in March and April, and the cultivation of the banana has added a profuse honey yielder, which puts forth successive blossoms all through the summer months.

Locust, tulip tree ("poplar," or whitewood), and *horse-chestnut*, useful for shade, ornament, and timber, are all fine honey producers in May. The locust yields light-colored, clear honey of fine quality, the others amber-colored honey of good body and fair flavor.

Clovers.—Crimson, blossoming in April or May, yields fine, light-colored honey; white, alsike, and mammoth or medium, blossoming in May, June, and July, give honey of excellent quality and rich yellow color.

Mustard grown for seed flowers from June to August. The honey is somewhat acrid and crystallizes soon, yet the plant, where abundant, is of much importance to the bees and the bee keeper in case other forage is scant at the time.

Asparagus blossoms are much visited by bees in June and July.

Esparecet, or *sainfoin*, yields in May and June fine honey, almost as clear as spring water. It is a perennial leguminous plant, rather hardy, an excellent forage crop, and particularly valuable for milch cows. It succeeds best on a limestone soil or when lime is used as a fertilizer, and is itself an excellent green manure for soils deficient in nitrogen and phosphoric acid.

Serradella is an annual leguminous plant which will grow on sandy land, and which yields, besides good forage, clear honey of good quality in June and July.

Chestnut, valuable for timber, ornament, shade, and nuts, yields honey and pollen in June or July.

Linden, *sourwood*, and *catalpa* are fine shade, ornamental, and timber trees, which yield great quantities of first quality honey in June and July.

Cotton.—In the South cotton blossoms, appearing as they do in succession during the whole summer, often yield considerable honey. It would appear, however, that when the plants are very rank in growth the blossoms—being correspondingly large—are too deep for the bees to reach the nectar.

Chicory, raised for salad and for its roots, is, whenever permitted to blossom, eagerly visited for honey in July and August.

Pot herbs, when allowed to blossom, nearly all yield honey in June, July, or August. Where fields of them are grown for the seed, the honey yield may be considerable from this source.

Alfalfa furnishes in the West a large amount of very fine honey during June and July. Its importance as a forage crop there is well known, but how far eastward its cultivation may be profitably extended is still a question, and even should it prove of value in the East as a forage plant it is still uncertain what its honey-producing qualities would be there.

Parsnips when left for seed blossom freely from June to August, inclusive, and are much frequented by honey bees.

Peppermint, raised for its foliage, from which oil is distilled, is most frequently cut before the bees derive much benefit from it, but when ever allowed to blossom it is eagerly sought after by them, and yields honey freely during July and August.

Bokhara, or *sweet clover*, is in some sections of the country considered a valuable forage crop. Animals can be taught to like it, and it is very valuable as a restorer of exhausted lime soils, while in regions lacking in bee pasturage during the summer months it is a very important addition. It withstands drouth remarkably well and yields a large quantity of fine honey.

Cucumber, squash, pumpkin, and melon blossoms furnish honey and some pollen to the bees in July and August.

Eucalypti, valuable for their timber and as ornaments to lawn and roadside, are quick-growing trees adapted to the southern portions of the United States. They yield much honey between July and October.

The *carob tree*, whose cultivation has been commenced in the Southwest, is an excellent honey yielder in late summer. It is an ornamental tree and gives, in addition to honey, another valuable product—the carob bean of commerce.

Sacaline, a forage and ornamental plant of recent introduction, is a great favorite with bees. It blossoms profusely during August, is a hardy perennial, and thrives in wet and also fairly in dry situations, withstanding the ordinary summer drouth of the Eastern States because of its deeply penetrating roots.

Buckwheat is an important honey and pollen producer. Its blossoms appear about four weeks after the seed is sown, hence it may be made to fill in a summer dearth of honey plants.

HOW TO OBTAIN SURPLUS HONEY AND WAX.

Good wintering, followed by careful conservation of the natural warmth of the colony, the presence of a prolific queen—preferably a young one—with abundant stores for brood rearing, are, together with the prevention, in so far as possible, of swarming, the prime conditions necessary to bring a colony of bees to the chief honey-flow in shape to enable it to take full advantage of the harvest. In addition it is only necessary to adjust the surplus honey receptacles in time, making the space given proportionate to the strength of the colony, and, while continuing to prevent as far as possible the issuance of swarms, to remove the accumulated honey fast enough to give abundant storage room.

EXTRACTED HONEY.

To secure extracted honey, the requisite number of combs may be in one long hive, or in stories one above another. Preference is most generally given to the latter plan. The brood apartment is made in this case to hold eight to twelve Langstroth frames, and a second, and sometimes a third or even a fourth story, may be added temporarily. These added stories may be for full-depth frames, or, for convenience in handling and in order to be able to control more closely the amount of space given, they may be half the usual depth, and but one of the half-depth stories added at a time. If numerous sets of combs are at hand, or if it is desirable to have others built, additional stories are put on as fast as the combs already occupied by the bees are filled. Before removing the filled combs time should be allowed the bees to ripen and cap the honey; hence enough combs are necessary to give the bees storage room while they are capping others. The honey in combs that are quite or nearly sealed over may be considered sufficiently ripened to be removed from the hive.

It should also be taken promptly, in order to keep the various grades or kinds separate. However, when the combs of a given super are completely filled and sealed it may be marked and left on the hive if more convenient to be extracted later.

The cells are uncapped by means of a sharp knife, made especially for this purpose (fig. 9), and the combs are then made to revolve rapidly in the honey extractor (fig. 10).

The centrifugal force exerted on the honey throws it out, leaving the comb cells uninjured, or so slightly injured that they are wholly repaired within an hour

or so after the return of the comb to the hive. The chief advantages of this method of harvesting over that of crushing the combs are at once apparent when it is known that each pound of comb saved represents several pounds of honey (consumed in its construction), and may, with care, be used over almost indefinitely in securing surplus honey. Furthermore, extracted honey is of much finer quality than that obtained by crushing the combs and straining out the liquid part, since it is free from crushed bees, larvæ, pollen or "bee bread," etc., which not only render strained honey dark and strong flavored, but also make it liable to ferment and sour.

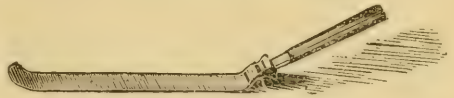


FIG. 9.—Quinby uncapping knife.

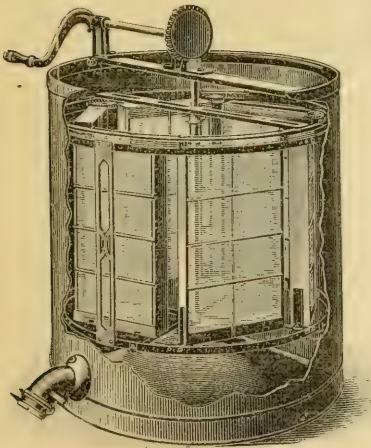


FIG. 10.—The Williams automatic reversible honey extractor.

The extracted honey is run into open buckets or tanks and left to stand a week or so in a dry, warm room. It should be skimmed each day until perfectly clear, and is then ready to be put into cans or barrels for marketing, or to be stored in a dry place. Square tin cans, each made to hold 60 pounds of extracted honey, are sold by dealers in apiarian supplies. This style of package is a convenient one to transport, and is also acceptable to dealers. Wooden shipping-cases are usually constructed so as to hold two of these cans. Barrels and kegs may be used, especially for the cheaper grades of honey used chiefly in the manufacture of other articles. They should be dry, made of well-seasoned, sound wood, and the hoops driven tight and secured, as well-ripened honey readily absorbs moisture from wood, causing shrinking and leaking. They should also be coated inside with beeswax or paraffin. This is easily done by warming the barrels and then pouring in a gallon or two of hot wax or paraffin, and, after having driven in the bungs tightly, rolling the barrels about a few times

and turning them on end. The work should be done quickly and the liquid not adhering to the inner surfaces poured out at once, in order to leave but a thin coating inside.

The surplus combs are to be removed at the close of the season and hung an inch or so apart on racks placed in a dry, airy room, where no artificial heat is felt. Mice, if permitted to reach them, will do considerable damage by gnawing away the cells containing pollen or those in which bees have been bred, and which therefore contain larval and pupal skins. Moth larvae are not likely to trouble them until the following spring, but upon the appearance of milder weather their ravages will begin, and if the combs can not be placed under the care of the bees at

once they must be fumigated with burning sulphur or with bisulphide of carbon.

COMB HONEY.

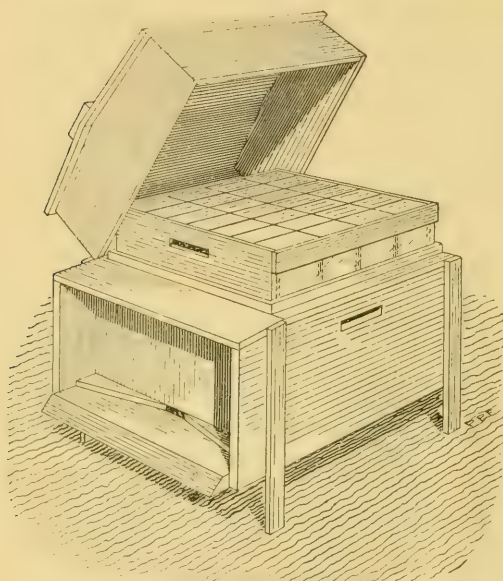


FIG. 11. Langstroth hive—super above holding 24 sections for comb honey.

The main difference to be observed in preparing colonies for the production of comb honey, instead of extracted, is in the adjustment of the brood apartment at the time the supers are added. After the colony has been bred up to the greatest possible strength, the brood apartment should be so regulated in size, when the honey-flow begins and the supers are added, as

to crowd many of the bees out and into the supers placed above.

On each hive a super is placed (fig. 11) holding 24 to 48 sections, each section supplied with a strip or a full sheet of very thin foundation. It is best not to give too much space at once, as considerable warmth is necessary to enable the bees to draw out foundation or to build comb. A single set of sections is usually sufficient at a time. When the honey is designed for home use or for a local market, half-depth frames are sometimes used, the same as those often used above the brood nests when colonies are run for extracted honey, but for the general market pound sections (fig. 12) are better adapted.

It is the practice of many to have nice white comb partially drawn out before the main honey flow begins, or even the season before, feed-

ing the colonies, if necessary, to secure this; and, when the honey yield begins, to supply sets of sections with these combs having cells deep enough for the bees to begin storing in as soon as any honey is collected. Earlier work in the sections is secured, and this, as is well known, is an important point in the prevention of swarming. Mr. Samuel Simmins, of England, has long contended for this use of partially drawn combs, and though it forms a feature of his system for the prevention of swarming it has been too often overlooked. Manufacturers of comb foundation are now endeavoring to meet this want by placing on the market foundation with an extremely thin septum, or base, and comparatively high side walls, which the bees thin down at once, using the extra wax to deepen the cells.

If the brood apartment has been much contracted when the supers were added, the queen may go into the sections and deposit eggs unless prevented by the insertion of a queen excluder (fig. 13). This, merely a sheet of zinc with perforations which permit workers, but not the queen, to pass, is placed between the brood apartment and the supers. The great inconvenience of having brood in some of the sections is thereby prevented. When

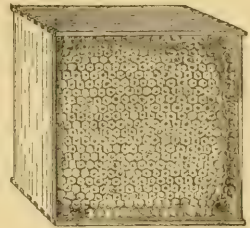


FIG. 12. Comb honey stored in pound section—size $4\frac{1}{4}$ by $4\frac{1}{4}$ inches.

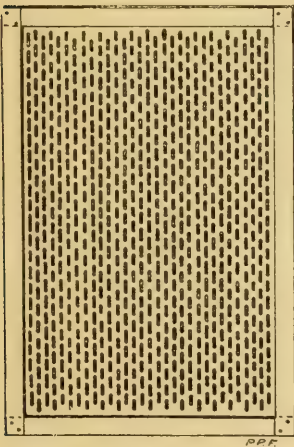


FIG. 13.—Perforated zinc queen-excluder.

the honey in the sections has been nearly capped over, the super may be lifted up and another added between it and the brood apartment. Or, should the strength of the colony not be sufficient or the harvest not abundant enough to warrant the giving of so much space, the sections which are completely finished may be removed and the partly finished ones used as "bait sections" to encourage work in another set of sections on this hive or in new supers elsewhere. The objections to the removal of sections one by one, and brushing the bees from them, are (1) the time it takes, and (2) the danger that the bees when disturbed, and especially if smoked, will bite open the capping and begin the removal of the honey,

thus injuring the appearance of the completed sections.

A recent valuable invention, the bee escape (fig. 3), the use of which is explained on page 8, when placed between the super and the brood nest, permits the bees then above the escape to go down into the brood apartment, but does not permit their reentering the super. If inserted twelve to twenty-four hours before the sections

are to be removed, the latter will be found free from bees at the time of removal, provided all brood has been kept out of the supers.

Grading and shipping comb honey.—Before marketing the honey it should be carefully graded, and all propolis ("bee-glue"), if there be any, scraped from the edges of the sections. In grading for the city markets the following rules are, in the main, observed. They were adopted by the North American Bee-Keepers' Association at its twenty-third annual convention, held in Washington, D. C., in December, 1892, and are copied from the official report of that meeting.

Fancy.—All sections to be well filled; combs straight, of even thickness, and firmly attached to all four sides; both wood and comb unsoiled by travel stain or otherwise; all cells sealed except the row of cells next to the wood.

No. 1.—All sections well filled, but with combs crooked or uneven, detached at the bottom, or with but few cells unsealed; both wood and comb unsoiled by travel stain or otherwise.

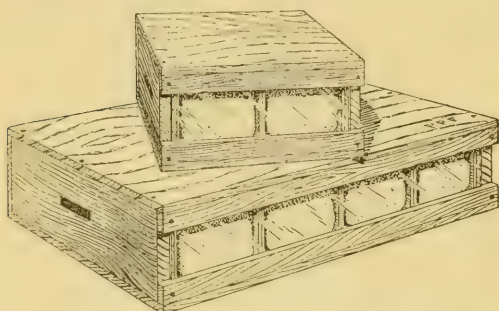


FIG. 14.—Shipping cases for comb honey.

In addition to the above, honey is to be classified, according to color, into light, amber, and dark. For instance, there will be "fancy light," "fancy amber," and "fancy dark," "No. 1 light," "No. 1 amber," and "No. 1 dark."

The sections, after grading and scraping, are to be

placed in clean shipping cases having glass in one or both ends (fig. 14). Several of these may be placed in a single crate for shipment. To prevent breaking down of the combs it is best to put straw in the bottom of the crate for the shipping cases to rest on, and the crates should be so placed as to keep the combs in a perpendicular position. The crates are also likely to be kept right side up if convenient handles are attached to the sides—preferably strips with the ends projecting beyond the corners. Care in handling will generally be given if the glass in the shipping cases shows.

PRODUCTION OF WAX.

No method has yet been brought forward which will enable one at the present relative prices of honey and wax to turn the whole working force of the bees, or even the greater part of it, into the production of wax instead of honey; in fact, the small amount of wax produced incidentally in apiaries managed for extracted or for section honey is usually turned into honey the following season; that is, it is made into comb foundation, which is then employed in the same hives to increase their yield of marketable honey. It is even the case that in most apiaries managed on approved modern methods more pounds of foundation are employed than wax produced; hence less progressive bee

keepers—those who adhere to the use of box hives and who can not therefore utilize comb foundation—are called upon for their wax product. As each pound of wax represents several pounds of honey, all cappings removed when preparing combs for the extractor, all scrapings and trimmings and bits of drone comb, are to be saved and rendered into wax. This is best done in the solar wax extractor (fig. 15), the essential parts of which are a metal tank with wire-cloth strainer and a glass cover, the latter generally made double. The bottom of the metal tank is strewn with pieces of comb, the glass cover adjusted, and the whole exposed to the direct rays of the sun. A superior quality of wax filters through the strainer.

Another method is to inclose the cappings or combs to be rendered in a coarse sack and weight this down in a tin boiler partly filled with rain water or soft spring water and boil slowly until little or no more wax can be pressed out of the material in the sack. Melting in an iron

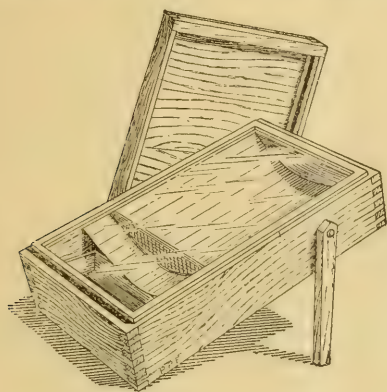


FIG. 15.—Solar wax-extractor.

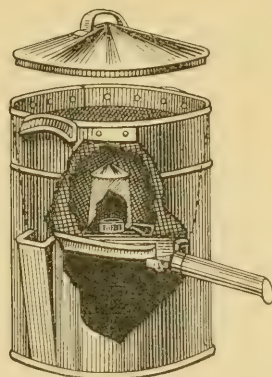


FIG. 16.—Steam wax-extractor.

receptacle makes the wax dark colored. A special utensil made of tin for use as a wax extractor (fig. 16) over boiling water can also be had. The bits of comb are placed in this in an inside can having fine perforations, through which the steam from below enters and melts out the wax, which drips from a spout into another receptacle partly filled with water, from the surface of which the cake of wax may be removed when cold.

THE WINTERING OF BEES.

How to bring bees successfully through the winter in the colder portions of the United States is a problem which gives anxiety to all who are about to attempt it for the first time in those sections, and even many who have kept bees for years still find it their greatest difficulty. It may happen occasionally that a queen, apparently young and vigorous in the autumn, will die during the winter, when a young one can not be reared, and as a result the colony will dwindle away. Such losses are, however, rare, and, aside from the possible results of fire,

flood, or violent storms, are about the only ones which can not be avoided by careful attention to right methods in wintering. Insufficient or poor winter stores, hives faulty in construction, lack of protection from cold and dampness, too much or too little ventilation, too great a proportion of old bees or too great a proportion of young ones, over-manipulation late in the season, etc., are the most important and most easily detected causes of loss in wintering bees. In some instances colonies supposed to have been placed in the same condition under which others have wintered well become diseased and die or dwindle away without prominent signs of disease. It is evident, however, that some condition existed in one case which was not present in the other, or that in spite of some unfavorable condition the favorable ones combined, in the first instance, to render the wintering successful.

In the South wintering in the open air on the summer stands is the only method followed, while in the colder portions of the country, although with proper precautions bees may be wintered successfully in the open air, many prefer to house them in special repositories built with double walls, or to place them in darkened cellars, or in clamps. Indoor wintering should be confined to regions where there are several weeks, at least, of continued severe weather. When all conditions are right, consumption of honey will be less indoors and loss of bee-life less than with the methods usually practiced in outdoor wintering. Under proper conditions, however, especially when abundant protection has been given, colonies out of doors will consume no more food nor meet with greater losses in numbers than those wintered under favorable conditions indoors. In wintering indoors certain essential conditions are, in a measure, beyond the control of the bee keeper, hence must be left to chance, and certain other conditions and emergencies liable to arise, though easily understood and met by the man of experience in this direction, are yet very likely to be overlooked by the novice or to be puzzling and disastrous to him. For these reasons it is safer for him to keep closer to the natural method at first and try outdoor wintering.

In wintering out of doors the conditions within the control of the bee keeper are more readily perceived and easier to meet, and though the original work of preparation for good wintering out of doors is greater per colony, yet the work during the winter itself and the following spring is likely to be less; moreover, the feeling of greater security, as well as the greater certainty of finding the colonies in good condition to begin gathering in the spring, are points well worthy of consideration. In other words, indoor wintering should be left to such experienced bee keepers as may prefer it and are located in cold climates, while novices, wherever located, should first endeavor to meet the requirements of successful outdoor wintering, that is, to prepare the colonies so that Nature, whatever her mood as regards the weather, will bring her tiny charges safely through the perils and vicissitudes of the winter months.

GENERAL CONSIDERATIONS.

Whatever method be followed in wintering, certain conditions regarding the colony itself are plainly essential: First, it should have a good queen; second, a fair-sized cluster of healthy bees, neither too old nor too young; third, a plentiful supply of good food. The first of these conditions may be counted as fulfilled if the queen at the head of the colony is less than two and one-half years old, is still active, and has always kept her colony populous; yet a younger queen—even one of the current season's rearing, and thus but a few weeks or months old—is, if raised under favorable conditions, to be preferred. The second point is met if brood-rearing has been continued without serious interruption during the latter part of the summer and the cluster of bees occupies on a cool day in autumn six to eight or more spaces between the combs, or forms a compact cluster 8 or 9 inches in diameter. Young bees, if not well protected by older ones, succumb readily to the cold, while quite old bees die early in the spring, and others, which emerged late in the summer or autumn preceding, are needed to replace them. The third essential—good food—is secured if the hive is liberally supplied with well-ripened honey from any source whatever, or with fairly thick sirup, made from white cane sugar, which was fed early enough to enable the bees to seal it over before they ceased flying. Fifteen to 20 pounds for outdoor wintering in the South, up to 30 or 40 pounds in the North, when wintered outside with but slight protection, or, if wintered indoors, 15 to 20 pounds may be considered a fair supply of winter food. A smaller amount should not be trusted except in case much greater protection be furnished against the effects of severe weather than is usually given. A greater amount of stores will do no harm if properly arranged over and about the center of the cluster, or, in case the combs are narrow, wholly above the cluster. In many instances it will be a benefit by equalizing in a measure the temperature in the hive, as well as by giving to the bees greater confidence in extending the brood nest in early spring.

INDOOR WINTERING.

A dry, dark cellar or special repository built in a sidehill or with double, filled walls, like those of an ice house, may be utilized for wintering bees in extremely cold climates. It should be so built that a temperature of 42 to 45° F. (the air being fairly dry in the cellar) can be maintained during the greater part of the winter. To this end it should be well drained, furnished with adjustable ventilators, and covered all over with earth, except the entrance, where close-fitting doors, preferably three of them, should open in succession, so as to separate the main room from the outside by a double entry way. The colonies, supplied with good queens, plenty of bees, 20 to 25 pounds of stores each, and with chaff cushions placed over the frames, are carried in shortly before snow and severe freezing weather come.

Any repository which is damp or one whose temperature falls below

freezing or remains long below 38° F. is not a suitable place in which to winter bees. When in repositories, the bees have no opportunity for a cleansing flight, nor do they, when the temperature rises outside, always warm up sufficiently to enable the cluster to move from combs from which the stores have been exhausted to full ones, hence in a cold repository they are liable to starve with plenty of food in the hive. As a rule, colonies would be better off out of doors in their summer hives than in such places.

OUTDOOR WINTERING.

Cold and dampness are the great winter enemies of bee life. A single bee can withstand very little cold, but a good cluster, if all other conditions are favorable, can defy the most rigorous winters of our coldest States. But if not thoroughly dry, even a moderate degree of cold is always injurious, if not absolutely fatal. Dampness in winter is therefore the most dangerous element with which the bee keeper has to contend. The matter would, of course, be quite simple if only that dampness which might come from the outside were to be considered, but when the air of the hive, somewhat warmed by the bees and more or less charged with the moisture of respiration, comes in contact with hive walls or comb surfaces made cold by outside air, condensation takes place, and the moisture trickles over the cold surfaces and cluster of bees, saturating the air about them or even drenching them, unless by forming a very compact cluster they are able to prevent it from penetrating, or by greater activity to raise the temperature sufficiently to evaporate the surplus moisture, or at least that portion near them. But this greater activity is, of course, at the expense of muscular power and requires the consumption of nitrogenous as well as carbonaceous food. Increased cold or its long continuance greatly aggravates conditions.

Nature has provided that the accumulation of waste products in the body of the bee during its winter confinement should be small under normal conditions, but unusual consumption of food, especially of a highly nitrogenous nature like pollen, necessitates a cleansing flight, or diarrheal difficulties ensue, combs and hives are soiled, the air of the hive becomes polluted, and at last the individual bees become too weak to generate proper warmth or drive off the surplus moisture which then invades the cluster and brings death to the colony; or, what is more frequently the case, a cold snap destroys the last remnant of the colony, which has been reduced by constant loss of bees impelled by disease to leave the cluster or even to venture out for a cleansing flight when snows and great cold prevail.

The problem then is: *To retain the warmth generated by the bees, which is necessary to their well-being, and at the same time to prevent the accumulation of moisture in the hive.* A simple opening at the top of the hive would permit much of the moisture to pass off, but of course heat would escape with it and a draft would be produced. Absorbent mate-

rial about the cluster creates, without free ventilation, damp surroundings, and again the temperature is lowered. It is only necessary, however, to surround the bees with sufficient material to protect them fully against the greatest cold liable to occur, and to take care also that this enveloping material is of such a nature and so disposed as to permit the free passage of the moisture which would otherwise collect in the interior of the hive, and to permit the escape into the surrounding atmosphere of such moisture as enters this material from within. This packing should also be fully protected from outside moisture.

South of Virginia, Kentucky, and Kansas single-walled hives may be employed in most localities with good success in outdoor wintering. On the approach of the cool or the rainy season a close-fitting quilt should be laid over the frames and several folded newspapers pressed down on this, or a cushion filled with dry chaff

or some other soft material may be used instead of paper. The cover or roof should be absolutely rain-proof, yet between this cover and the cushion or papers should be several inches of space with free circulation of air. In order to permit this ventilation above the top packing the cover should not rest upon the cap or upper story all of the

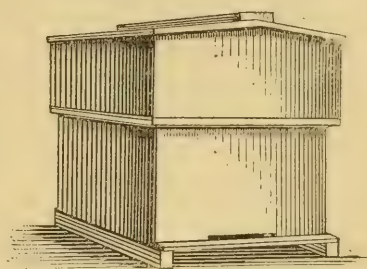


FIG. 17.—Double-walled hive adapted to outdoor wintering as well as summer use below 40° north latitude in the United States. Thickness of each wall, $\frac{3}{8}$ inch; space between walls, 2 inches, packed with dry chaff or ground cork.

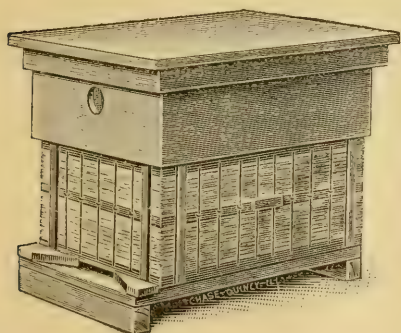


FIG. 18.—The American straw hive (Langstroth principle) of Hayck Brothers.

way around, or if it does, an auger hole in each end, protected by wire cloth against the entrance of mice, should give free passage to the air. In the more northern portion of the section referred to some further protection is advisable (fig. 17), and is really necessary in the mountainous parts of the same territory if the best results are to be obtained. Farther north, and especially in the cold Northwest, much greater protection becomes an absolute necessity. Quilts with newspapers or

thin packing above do not alone suffice. The side walls of the hive may be made of pressed straw (fig. 18). These, with top packing, if kept dry outside, are excellent for outdoor wintering, even in climates so cold that ordinary wooden hives do not afford sufficient protection.

In the severest climates, however, still greater protection on all sides of the colony is needed, and packing with chaff or other soft material

is decidedly the best plan. The thickness of this surrounding packing should be from 2 inches to 8 or 10 inches for single colonies, according to the severity of the climate, but if four or more colonies are grouped for the winter, so as to make the natural warmth generated mutually advantageous, somewhat less packing will be sufficient. A most important point is to have the soft warmth-retaining packing come in close contact with the edges of the combs, and above all *not to have a hive wall, either thick or thin, between this material and the bees.* A good plan is to construct an open framework or skeleton hive of laths, cover it with sacking, or, preferably, some less fuzzy cloth which the bees will not gnaw, and, after placing it in an outer wooden case large enough

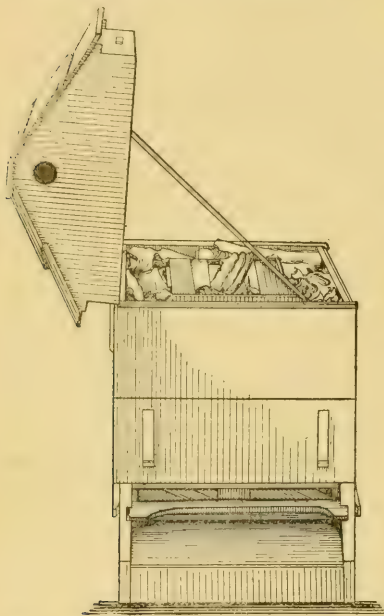


FIG. 19.—Colony of bees with newspapers packed between inner and outer cases and brood frames on end for the winter.

every way to admit of the necessary packing about the colony, to fill in on all sides with some dry, porous material (fig. 19). If the frames are shallow, like the Langstroth, it is better to construct the inner case so as to place them on end, and thus give a deeper comb for the winter. Layers of newspapers may come next outside the cloth covering of the framework. Wheat chaff answers well to complete the packing. Wool is to be preferred, but is of course too expensive unless a waste product. Ground cork, waste flax, hemp, sawdust, etc., in fact, any fine porous material, if thoroughly dry, may be used.

A board passageway 3 or 4 inches wide and three-eighths of an inch high should connect this inner apartment and the flight hole of the outer case, thus affording an exit for the bees whenever the weather may permit them to fly. When these prep-

arations have been completed, the hive is ready for the combs, which with adhering bees, are taken from the summer hive and inserted in the winter hive. A quilt is then laid on the frames and the top packing put on. This, for convenience, may be held in a cloth-bottomed tray. It is quite important, as already mentioned, that air be allowed to circulate freely above the packing. The outside case must be quite rain-proof or else wholly protected from the rain by a roof.

All other necessary conditions having been complied with shortly after the gathering season closed, the combs may be lifted from the summer hives and placed in these specially arranged winter cases before cold weather wholly stops the bees from flying out. Thus pre-

pared for the winter the colonies will need but slight attention from October until March, or, in the North, even later, and the losses will be limited to the small percentage of cases due to failure of apparently good queens.

THE RISK OF LOSS THROUGH DISEASE AND ENEMIES.

Winter losses through disease superinduced by unfavorable surroundings which it is within the power of the bee keeper to avoid have already been considered. But one other serious disease has been widespread. This is a highly contagious affection which, as it mainly affects the developing brood in the cells, is commonly known as "foul brood." It is due to a microbe (*Bacillus alvei*) whose spores are easily transported from hive to hive by the bees themselves, by the operator, in honey, or in combs changed from one hive to another. Once established in an apiary, it usually spreads, unless speedily and energetically checked, until all of the colonies in the neighborhood are ruined and even exterminated. The most apparent symptoms are the turning black of larvæ in open cells, many sealed cells with sunken caps, frequently broken in and containing dead larvæ or pupæ in a putrid condition, brown or coffee-colored, jelly-like or ropy in consistency, and giving off an offensive odor. The disease, though known to exist in nearly all countries, can hardly be said to be common. The writer, in an experience of over thirty years in bee keeping in several States of the Union, as well as in a number of foreign countries, has met the disease but rarely, and has had but one experience with it in his own apiary, it having been in this instance brought in by a neighbor who purchased bees at a distance. It was easily cured, without great loss. Thus the beginner's risks of disaster in this direction are, if he be forewarned, comparatively small. He may, furthermore, gain assurance from the fact that, should the disease invade his apiary, prompt and intelligent action will prevent serious loss.

The following is the treatment for a colony which still has sufficient strength of numbers to be worth saving: The bees are to be shaken from their combs just at nightfall into an empty box, which is to be removed at once to a cool, dark place. The bees are to be confined to the box, but it must be well ventilated through openings covered with wire cloth. During the first forty-eight hours no food should be given to them, and during the second forty-eight hours only a small amount of medicated sirup—a half pint daily for a small colony to a pint for a strong one. This food is prepared by adding one part of pure carbolic acid or phenol to 600 or 700 parts of sugar sirup or honey. At the end of the fourth day the bees are to be shaken into a clean hive supplied with starters of comb foundation. This hive is to be placed outside on a stand some distance from all other colonies, and moderate feeding with medicated sirup or honey should be continued for a few days thereafter. The combs and frames taken from the diseased colony at

the start, as well as all of the pieces built during the four days' confinement, should be burned. The honey from the affected hive may be heated to the boiling point in a water bath and used for feeding bees. The old hive and all utensils used about the diseased colony should be disinfected by washing in a solution of corrosive sublimate—one-eighth ounce in one gallon of water—and should afterwards be exposed to the air and sun for some time. If healthy colonies are to be manipulated immediately after handling diseased ones the hands of the operator must also be disinfected by washing in the solution just mentioned.

Those who care to try and save combs and brood should employ the remedial method developed by the late Professor Cheshire. This is explained in full in his work on bee keeping,¹ and a brief statement of it may also be found in "The Honey Bee," Bulletin No. 1, new series, of the Division of Entomology, United States Department of Agriculture. Notwithstanding these remedies, some will prefer, where healthy colonies of bees can be bought at moderate prices, to burn diseased bees, combs, and frames rather than spend time to effect a cure and risk, as they fear they may, the further spread of the pest. To kill the bees thus is, however, neither profitable, humane, nor necessary, for if confined as described above and separated at once from the other colonies, this work being done at nightfall, when all of the bees are in their hives, the risk of spreading the disease will not thereby be increased, nor is the labor much greater than that involved in the removal of combs and bees for burning. And if it be found that the diseased colonies are weak in numbers and seem, therefore, individually hardly worth saving, this need not be taken as an excuse for the death sentence, as several colonies may be smoked and shaken together into the same box to make a single strong colony, the best queen of the lot having been selected and caged in the box in such a way that the workers can release her within a few hours by eating through candy.

Other bacterial diseases, though existing, have developed only very locally or have been too limited in the amount of injury inflicted to require special mention here.

The bee or wax moth (*Galleria mellonella* Linn.) is regarded by those unfamiliar with modern methods in bee keeping as a very serious enemy to success in this work. It was frequently such when only the common black bee was kept and the old way of managing, or rather of trusting to luck, was followed. But with the better races now introduced and with improved hives and methods, and especially with the care that is now given to have no colonies queenless long at a time, the wax-moth larvæ are no longer regarded with great concern.

Some species of wasps take a little honey at times—more particularly when hives are opened—and they annoy the bees; others capture and eat workers, as do also the large ant like "cow-killers" (Mutillidæ), and

¹"Bees and Bee-keeping," by Frank R. Cheshire, F. L. S., F. R. M. S., London, 1888, Vol. II, page 554-575.

certain predaceous flies (*Asilidae*), true bugs (*Phymatidae*), and neuropterous and orthopterous insects (*Libellulidae* and *Mantidae*). The larvæ of certain beetles (*Dermestidae* and *Tenebrio*) feed upon pollen and the cast-off skins of developing larvæ and pupæ, and certain of the Meloid larvæ attach themselves to the bodies of bees as parasites. Ants (*Formicidae*) and cockroaches (*Blattidae*), which gather above the quilts and between the quilts and the tops of the frames in order to be benefited by the warmth of the cluster of bees, sometimes help themselves to honey, and their presence annoys the bees more or less. Some of the insects here mentioned are only found locally, the predaceous ones being confined mainly to the South, while it may be said that the general welfare of strong colonies is not often materially affected nor the return noticeably reduced through the attacks of any or all of them.

Spiders, toads, and lizards destroy, in addition to many injurious insects, also some bees, and should be tolerated in the vegetable garden rather than in the apiary.

Swallows, kingbirds or bee martins, mice, skunks, and bears only occasionally commit depredations in the apiary.

Properly constructed hives enable the bees to limit in a great measure the injury which these various enemies might inflict, and the avoidance of overswarming, with care to insure the constant presence of a prolific queen and a supply of food suited to the needs of the colony at the time, will keep it populous and therefore in shape to repel attacks or to make good most of the unavoidable losses.

Robbing is sometimes a more serious matter, although it very rarely happens that a little careful attention just at the right time on the part of the bee keeper would not avoid all serious trouble on this score. When bees find nothing to gather during weather when they can still fly out they are easily tempted to appropriate the stores of weaker colonies. Exposure of combs of honey at such times may even occasion a combined attack upon a good colony otherwise quite able to take care of itself. It is then that the greatest destruction ensues, for such a colony will defend itself vigorously, and a pitched battle, with perhaps fifty or sixty thousand Amazons on either side, leaves the ground literally strewn with dead and dying.

If the invaders conquer, every drop of honey is taken from the few vanquished that are likely to be still alive; and in turn the despoilers invariably fight among themselves as to the possession of the booty. When the robbing takes place during the absence of the owner, the condition of the robbed colony may not attract immediate attention, and during warm weather moth larvæ gain full possession of the combs within a few days. When this condition is observed, the whole damage is very likely to be attributed to the moth larvæ. Colonies that have been left queenless for some time, and those weakened by disease or by overswarming are especial marks for such attacks. Of course these

defects should be remedied whenever observed, but meanwhile, if legitimate fieldwork is likely to be interrupted, every colony should be assisted in protecting itself against assault by having its hive made secure and the entrance such a narrow pass as to enable a few workers to repel attack there.

Should robbers get well started before being observed, the entrance of the hive should be narrowed at once, and wet grass or weeds may be thrown loosely over it, or a pane of glass may be stood against the front of the hive in a slanting manner to confuse the intruders. In extreme cases the attacked colonies may be removed to a cellar for a few days, plenty of ventilation being given during confinement, and a new location, apart from other colonies, selected, on which they are to be placed just at nightfall; or, instead of putting them in the cellar, they may be taken a mile or more away and returned only when the danger has passed. With these precautions, little loss is to be feared on this score.

In general the intelligent owner who gives careful attention to certain important points in bee management finds that he very rarely has disease to contend with, and that the reduction of profits through the depredations of bee enemies is not, in most parts of the Union, a serious discouragement. Altogether it seems to the writer that the risks in these directions are even less in bee keeping than those usually met in the keeping of other animals, which, like bees, are legitimately made to contribute to the wealth of the individual and of the nation.

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U. S. DEPARTMENT OF AGRICULTURE.

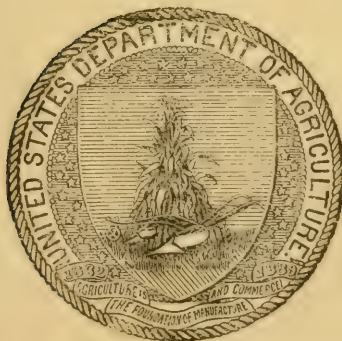
FARMERS' BULLETIN No. 59.

BEE KEEPING.

BY

FRANK BENTON, M. S.,
IN CHARGE OF APICULTURAL INVESTIGATIONS.

[Revised, March, 1905.]



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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY,

Washington, D. C., March 24, 1905.

SIR: Frequent inquiries from correspondents of the Department of Agriculture for information on matters pertaining to the culture of bees, and particularly as to the conditions under which one may reasonably expect to meet with success in this pursuit, led to the preparation of this bulletin in July, 1897. Though designed by the author primarily to answer a few of the specific questions which are most likely to present themselves to the mind of the inquirer wholly unfamiliar with the subject, the aim has been also to introduce in the treatment of the various topics information which it is hoped will lead many of longer experience into more successful methods than they have yet practiced. The stereotype plates of the earlier editions having become much worn, necessitating the resetting of the type of the entire bulletin, the opportunity has been afforded of inserting several new paragraphs and making a few slight changes in the text as heretofore published.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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BEE KEEPING.

LOCATIONS SUITED TO THE KEEPING OF BEES.

It may be safely said that any place where farming, gardening, or fruit raising can be successfully followed is adapted to the profitable keeping of bees—in a limited way at least, if not extensively. Many of these localities will support extensive apiaries. In addition to this there are, within the borders of the United States, thousands of good locations for the apiarist—forest, prairie, swamp, and mountain regions—where agriculture has as yet not gained a foothold, either because of remoteness from markets or the uninviting character of soil or climate. This pursuit may also be followed in or near towns and, to a limited extent, in large cities. It even happens in some instances that bees in cities or towns find more abundant pasturage than in country locations which are considered fair.

The city of Washington is an example of this, bees located here doing better during the spring and summer months than those in the surrounding country, owing to the bee pasturage found in the numerous gardens and parks and the nectar-yielding shade trees along the streets. This is due mainly to the fact that the linden, or basswood, which is rarely seen in the country about Washington, has been planted extensively in the parks and for miles on both sides of many of the streets and avenues of the city.^a Another source in the city not found extensively in the country adjacent is melilot, Bokhara or sweet clover (*Melilotus alba*), which has crept into vacant lots and neglected corners, and diffuses its agreeable perfume to the delight of all city dwellers, whether human or insect. The writer has practiced with profit the transportation of nearly a hundred colonies from a country apiary 10 miles distant to Washington for the linden and sweet clover yield. He has also seen a prosperous apiary kept on the roof of a business house in the heart of New York City, and on several occasions has visited another apiary of 30 to 40 colonies, which a skillful apiarist had located on the roof of his store in the business portion of Cincinnati, Ohio, and from which 30 to 40 pounds of honey per colony were usually obtained each year.

^a Several species of lindens are included in these plantings, but none yields more than our common American linden, or basswood (*Tilia americana*).

Another apiary personally inspected was located directly on the sand banks forming the eastern shore of Lake Michigan. These bees were, of course, unable to forage westward from the apiary, hence had but half "a field." The soil of the area over which the bees ranged was a light sand, unproductive for most crops, and the region was little developed agriculturally, most of the honey coming from forest trees and from shrubs and wild plants growing in old burnings and windfalls, yet 25 to 30 pounds of excellent honey per colony was the usual surplus obtained. At one time the writer had an apiary in the city of Detroit, Mich., where the wide river on one side cut off nearly half of the pasturage, yet the bees did will. And again for several years he had an apiary containing from 100 to 200 colonies of bees on a very sterile coast of the Island of Cyprus, and another nearly as large located but a few rods from the seashore on a rocky point of Syria. Both of these apiaries were devoted in the main to queen rearing, yet the yield of honey was not an unimportant item, especially in the Syrian apiary, while in the Cyprus apiary some honey was frequently taken, and it was rarely necessary to feed the bees for stores. In the latter case about one-fourth of the range was cut off by the sea, the bees being located at the head of an open bay and a short distance from the shore, while the location of the Syrian apiary prevented the bees from securing half of the usual range, hence their greater prosperity was due to the nature and quantity of the pasturage of their limited range.

It is evident, therefore, that no one similarly located need be deterred from keeping bees, provided the nectar-yielding trees and plants of the half range are of the right sort and abundant. Moreover, regions so rough and sterile or so swampy as to give no encouragement to the agriculturist, or even to the stock raiser, will often yield a good income to the bee keeper, insignificant and apparently worthless herbs and shrubs furnishing forage for the bees. The ability of the bees to range over areas inaccessible to other farm stock and to draw their sustenance from dense forests when the timber is of the right kind, and the freedom which, because of their nature, must be accorded them to pasture on whatever natural sources are within their range of 3 or 4 miles, must be taken into account in estimating the possibilities of a locality. It will be found that very few localities exist in our country where at least a few colonies of bees may not be kept. Whether a large number might be profitably kept in a given locality can be decided only by a careful examination as to the honey-producing flora within range of the apiary (see pp. 12 and 26-29).

The danger of overstocking a given locality is very frequently exaggerated. Each range, it is self-evident, has a limit. The writer is, however, fully convinced, after long experience in numerous localities and under the most varied circumstances, that three or four times as many colonies as are commonly considered sufficient to stock a given

range may usually be kept with a relative degree of profit. But to secure such results sufficient care and close observation have too frequently not been given in the selection of bees adapted to the locality and conditions. A more frequent failure has been lack of proper attention to the individual colonies, particularly as to the age and character of the queens in each. The space given for brood rearing is often too small, and frequently no care is given to secure the proper amount of brood in time to insure a population ready for each harvest. Attention to these points would enable great numbers of bee keepers who now regard 50 to 100 colonies as fully stocking their range to reach several hundreds in a single apiary, with slight or no diminution in the average yield per colony.

THE RETURNS TO BE EXPECTED FROM AN APIARY.

Although apiculture is extremely fascinating to most people who have a taste for the study of nature, requiring, as it does, out-of-door life, with enough exercise to be of benefit to one whose main occupation is sedentary, the income to be derived from it when rightly followed is a consideration which generally has some weight and is often the chief factor in leading one to undertake the care of bees. Certainly, where large apiaries are planned, the prime object is the material profit, for they require much hard labor and great watchfulness, and the performance of the work at stated times is imperative, so that in this case there is less opportunity than where but a few colonies are kept to make a leisurely study of the natural history and habits of these interesting insects, because—unless the keeper is willing to forego a considerable portion of his profits—his time must necessarily be almost wholly taken up in attending to the most apparent wants of his charges.

One very naturally supposes that the return from a single hive, or several of them, in a given locality, may be taken as a fair index of what may be expected each season. Such return, if considered average, may serve as a basis on which to reckon, but as so many conditions influence it, great differences in actual results will be found to occur in successive seasons. Apiculture, like all other branches of agriculture, depends largely upon the natural resources of the location, and the favorableness or unfavorableness of any particular season, no matter how skillful the management, may make great differences in the year's return. The knowledge, skill, industry, and promptness of the one who undertakes the care of the apiary have likewise much to do with the return. Furthermore, profits are of course largely affected by the nature and proximity of the markets.

A moderate estimate for a fairly good locality would be 35 to 40 pounds of extracted honey or 25 pounds of comb honey per colony.

This presupposes good wintering and an average season. When two or more of the important honey-yielding plants are present in abundance and are fairly supplemented by minor miscellaneous honey plants the locality may be considered excellent, and an expectation of realizing more than the yield mentioned above may be entertained. With extracted honey of good quality at its present wholesale price of 6 to 8 cents per pound and comb honey at 12 to 14 cents, each hive should under favorable circumstances give a gross annual return of \$2.50 to \$3. From this about one-third is to be deducted to cover expenses other than the item of labor. These will include the purchase of comb foundation and sections, repairs, eventual replacing of hives and implements, and the interest on the capital invested. By locating in some section particularly favorable to apiculture—that is, near large linden forests, with clover fields within range, supplemented by buckwheat; or in a section where alfalfa is raised for seed; where mesquite, California sages, and wild buckwheat abound; where mangrove, palmettoes, and titi, or where sourwood, tuliptree, and asters are plentiful—the net profits here indicated may frequently be doubled or trebled.

But these favored locations, like all others, are also subject to reverses—the result of droughts, great wet, freezes which kill back the bee pasturage, etc., and though some years the profits are so much larger than those named above as to lend a very roseate hue to the outlook for the accumulation of wealth on the part of anyone who can possess himself of a hundred or two colonies of bees, the beginner will do well to proceed cautiously, bearing in mind that much experience is necessary to enable him to turn to the best account seasons below the average, while during poor seasons it will take considerable understanding of the subject, energetic action, and some sacrifice to tide over, without disaster, or at least without such great discouragement as to cause neglect and loss of faith in the business. On the whole, there should be expected from the raising of bees for any purpose whatever only fair pay for one's time, good interest on the money invested, and a sufficient margin to cover contingencies. With no greater expectations from it than this, and where intelligence directs the work, apiculture will be found, in the long run, to rank among the best and safest of rural industries.

The value of bees in the pollination of various fruit and seed crops is often sufficient reason to warrant the keeping of a small apiary, even if circumstances do not favor its management in such a manner as to secure the largest possible crops of honey or to insure the saving of all swarms. The quality and quantity of many varieties of apples, pears, plums, and small fruits depend absolutely upon complete cross-pollination. The most active agents in this work are honey bees.

ANYONE WHO DESIRES TO DO SO CAN LEARN TO MANIPULATE BEES.

Any person with fairly steady nerves and some patience and courage can easily learn to control and manipulate bees. There are, it is true, a few exceptional individuals whose systems are particularly susceptible to the poison injected by the bee, so much so that serious effects follow a single sting. Such cases are, however, very rare. In most instances where care is not taken to avoid all stings the system eventually becomes accustomed to the poison, so that beyond momentary pain a sting causes no inconvenience.

To a certain extent the belief exists that bees have, without apparent cause, a violent dislike for some people, while others, without any effort, are received into their favor. The latter part of this proposition has a better foundation than the first part, for it is the actions, rather than any peculiarity of the individual himself, that anger the bees.

Bees prefer, of course, not to be disturbed; hence they usually keep guards on the lookout for intruders. When visitors approach the hives these guards are very apt to fly toward them as if to inquire whether harm is intended or not, and should the visitor not inspire them with fear by using smoke or some similar means, but should himself show fear and nervousness, he will be very likely to arouse their suspicions still further, or even to anger them should he strike at them or endeavor to dodge their approach. Indeed, one not accustomed to the notes of bees is very likely, unconsciously, to dodge his head about when a worker buzzes uncomfortably close to his face. It may be a movement of but an inch or two, but perhaps a quick jerk, and being noticed by the suspicious guard is resented; a sting follows, and yet the recipient declares that he did nothing to cause the attack, but that bees merely hate him and always sting him when he approaches them. On the other hand, an equally unprotected person who moves about with deliberation may generally, under the same circumstances, be let off without receiving a sting. It is in this case not so much what he does as what he does not do.

It is not to be understood that bees will always refrain from stinging if one remains somewhat passive in the vicinity of their hives, for the fact is that at some seasons common black bees and crosses having blood of this race fly some distance to attack passers-by, or even, without just provocation and with but slight warning, to plant a sting in the face of one who is standing near the apiary. But as the avoidance of such unpleasant occurrences depends largely upon the kind of bees kept, and, to a certain extent, upon an acquaintance with a few facts with which anyone of intelligence may easily familiarize himself, and the observance of certain precautions which are quite simple and after

a little practice will become easy, and as the opening and manipulation of hives in securing honey, etc., is equally simple and attended with no greater risks, it is safe to say that almost anyone can, with perseverance and the exercise of due caution, learn to manipulate bees with perfect freedom and without serious risk of being stung.

HOW TO AVOID STINGS.

Stings can be avoided, first, by having gentle bees. If no other point of superiority over the common brown or black bee than that of gentleness could be fairly claimed for some of the races introduced and some of the strains developed in recent years, it would still be worth while to get them on this account alone. When the fact of superiority in several other important points is considered also, there should be no further question as to the advisability of procuring them in preference to the common variety. The beginner is advised never to think of doing otherwise. No one likes stings, and even the veteran who affects

insensibility to the wrath of his charges will find his interest and pleasure in them much increased by replacing blacks and their crosses with better varieties. Nor is this

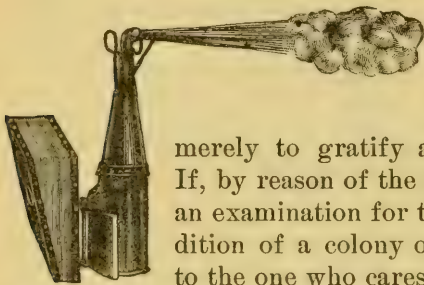


FIG. 1.—The Bingham bee smoker.

merely to gratify a fancy or for convenience alone. If, by reason of the stinging qualities of the bees kept, an examination for the purpose of ascertaining the condition of a colony of bees becomes a disagreeable task to the one who cares for the apiary, little things necessary to the welfare of the colonies will be postponed or omitted altogether and the apiary will soon present a neglected appearance, and the actual profits will be affected.

Of the races already in general cultivation, Carniolans are the gentlest, although Caucasians, more recently introduced from south-eastern Russia and only now being put on sale, are by far the least inclined to sting of any bees, and may be handled at all times without resorting to the protection of a bee veil, and generally without smoke, or at most a very slight application of smoke. Some strains of Italians equal in gentleness average Carniolans, but in general the race native to Italy is by no means as gentle as that found in Carniola, Austria, and the Caucasians are much to be preferred for the beginner. In case these gentler races are not easily procurable he need not hesitate, however, to undertake, after adopting due precautions, the manipulation of pure Italians.

In crossing well-established breeds the males of a gentle race should be used, otherwise the workers of the cross may vary greatly in temper, especially in the first few generations. Only careful selection

continued for some time will so fix the desirable traits as to result in their reproduction with a fair degree of certainty in the offspring. Bees having the blood of blacks and Italians are nearly always quite vicious in the case of the first cross, and are even harder to subdue with smoke than are pure blacks. Other races need not be considered here, as they are adapted to special purposes; and the skill of the bee-master, the conditions of climate, flora, etc., and the particular line of production to be followed, should decide whether their introduction is advisable or not.^a

The second essential to enable one to avoid stings is to have a good smoker at hand whenever the bees are to be handled. Any way of getting smoke of any kind into the hive and about it may answer the purpose, but for ease and effectiveness in keeping bees under control nothing will take the place of the modern bellows smoker (fig. 1). A good one lasts years, and its cost is so slight (\$1 to \$1.25 for the medium sizes) that the expenditure may be considered one of the wisest that can be made in fitting up an apiary.

A veil (fig. 2), made of black bobinet or Brussels net, to draw over the hat, and a pair of gloves, preferably of rubber, may be used at first. But whoever has fairly peaceable bees and learns even a little about their ways will soon discard the gloves, unless, indeed, he be exceedingly timid, or one of those to whom a bee sting would be a dreadful affliction. The veil can be safely dispensed with if the gentlest bees are kept.



FIG. 2.—Bee veil.

Simple and convenient hives, employing the Langstroth principle, and with stories and frames interchangeable and so constructed as to reduce propolization to a minimum and to insure straight combs, will much facilitate the avoidance of stings.

The use of the bee escape (fig. 3) in removing surplus honey greatly reduces the risk of being stung during this operation, for it saves much manipulation of combs and shaking and brushing of bees. This useful device is fitted into a slot made in a board the same size as the top of the hive, and the whole, when slipped in between the brood apartment and an upper story or super, will permit all of the workers above to go down into the lower story but not to return to the top

^a For a fuller discussion of this subject, see "The Honey Bee: A Manual of Instruction in Apiculture," by Frank Benton, M. S., Bulletin No. 1, new series, Bureau of Entomology, U. S. Dept. of Agriculture, third edition, 1899, Chap. I, pp. 11-18.

one, so that in one night it is possible to free entirely a set of combs from bees without any manipulation of the combs, and without smoking, shaking, or brushing the bees.

Lastly, reasonable care in manipulation and a suitable system of management, which, of course, implies the doing of work in proper season, will, with the observance of the foregoing points, make the risk of stings exceedingly slight. Indeed, intelligent attention to the most important of the points mentioned above, with extra gentleness and moderation in manipulation, will enable anyone who so desires to avoid all stings.

WHAT RACE OF BEES TO CHOOSE.

Reference has already been made to the relative gentleness of the various races, and since the gentler types are themselves excellent honey gatherers, and the particular advantages to be derived from some of the more energetic races which do not happen to be so mild in temperament are not likely to be secured by the beginner who is unfamiliar with the most approved methods of manipulation of such

bees, it is strongly recommended that only the gentle ones be at first adopted—either Caucasians, Carniolans, or Italians. Should full colonies of these not be obtainable near home, colonies of ordinary bees may be changed by re-



FIG. 3.—The Porter spring bee escape.

placing their queens with queens of the desired race, the latter having been procured in small boxes by mail. If possible the introduction had better be made by an expert, although in general, by following the instructions which accompany the new queen, success will also be attained by the beginner.

A brief summary of the leading traits of the various races now in this country will be of use in guiding the purchaser, as well as instructive to him for reference.

Caucasians are natives of that portion of Russia lying between the Black and Caspian seas, are exceedingly gentle, good workers, good defenders of their hives, prolific, build many queen cells, and swarm often if confined to small hives. The workers are dark leaden gray in their general color, and present quite a ringed appearance because of the alternation of this dark color with the lighter fuzz which edges the segments of the abdomen. They also show frequently one to two yellow or leather-colored bands, are somewhat smaller bodied than Italians or Carniolans, have good wing-expanse, and hence are nimble flyers. The drones are rather small and quite dark in color; queens not large, and vary in color from a coppery-yellow to a dark bronze.

Carniolans are much larger bodied and somewhat lighter gray in color than the Caucasians, but show likewise in many instances one or two rusty or dark-red bands. Their great hardiness and excellent wing power enable them to fly freely in much cooler weather than some other races stand, and to regain their hive entrances under adverse conditions. They are prolific, active, and good honey gatherers, producing combs of snowy whiteness. As in the case of the Caucasians, their prolificness causes them to fill small hives to overflowing with bees, and this naturally results in numerous swarms. It is therefore advisable to use hives containing ten to twelve frames in the brood chamber. The nature of the Carniolans is essentially a quiet one, so that upon the approach of cold weather they settle down in a very compact and extremely quiet cluster, a condition which contributes in no small degree to their excellent wintering qualities. The drones are the largest of all drones of this species, and are covered with a thick coat of gray fuzz. The queens vary from a light color to a very dark leather color, the typical queen being, however, dark bronze, large, well rounded, strong, and active.

Italians, the first of the foreign races to be introduced into this country, are much more widely known, and have with reason found great favor, since they are industrious, good defenders of their hives, and excellent honey gatherers, as well as handsome in appearance, being usually evenly marked with three yellow bands across the anterior portion of the abdomen. The blood has become so disseminated through the apiaries of the country that many hybrid bees having but one to two yellow bands are counted as Italians, and their cross disposition, derived through the males of the common race, is charged to the Italians. Strains of Italians pure in blood have been bred by selection in this country until the three yellow bands have become so wide as to be nearly or quite joined, and in some instances nearly the whole abdomen is yellow. In general, however, as regards gathering powers it does not seem that any improvement has been made by this selection, the dark or leather-colored Italians proving, all in all, more vigorous, gentle, and better honey gatherers, while as regards wintering they are also superior. It must be acknowledged, however, that the Italian race is slightly inferior in wintering qualities to all of the others which have been generally introduced into America.

Cyprians, from the island of Cyprus, may be taken as a general type with which to compare other eastern races. They are small bodied, more slender, in fact, than any of the European races of bees. The abdomen is more pointed and shows, when the bees are purely bred, three light-colored bands on the upper surface, and considerable yellow on the under side. Between the wing attachments on the thorax

is a little prominence, shaped like a half moon, which is usually quite plainly yellow in color. The queens are small bodied, yellow in color, with more or less black at the tip of the abdomen. The drones have a heavy coat of fuzz on the thorax, and the abdomen presents a mottled yellow appearance, being often highly yellow. Cyprians possess longer tongues and greater wing-power than other races. This, combined with great prolificness and most remarkable activity, renders them the best of honey gatherers. In temper, however, they may be regarded as rather aggressive, rendering their management by any who are not experts extremely difficult. This feature may, however, be largely overcome by crossing the queens of this race with the drones of very gentle types. In this manner bees are produced that are readily amenable to smoke and ordinary methods in manipulation, combined with the excellent honey-gathering powers and prolificness of the eastern races.

Cyprio-Carniolans and Cyprio-Caucasians.—The author conceived the idea in the early eighties that by crossing the Cyprian and Carniolan races a type might be developed which would combine the excellent traits of both of these. The first matings of Cyprians and Carniolans were made by him in 1883 in Carniola itself, thus insuring positively the fecundation of the Cyprian queens by Carniolan drones. Bees combining the blood of the two races in various proportions have since been tested for years in comparison with all other known races, with the result that the cross mentioned above has been found to exceed all of the pure races in honey-gathering powers, owing undoubtedly to the combination of great energy, hardiness, prolificness, and wing-power, as well as greater length of tongue—a fact established by actual measurements. Similar results, with even greater gentleness, may be expected from the cross obtained between Cyprian queens and Caucasian drones.

Syrian and Palestine or "Holy-Land" bees.—What has been said of Cyprians may be taken to apply in a general sense to Syrian and Palestine bees, except that in these the good qualities are slightly less prominent, while some of the bad ones of the Cyprians are accentuated. No separate description of these is, therefore, particularly necessary in this place.

German, Common Black, or Brown bees.—The bees commonly found wild, and cultivated to a greater or less extent, in this country, and known under the above name, are probably derived from early introductions from the Old World. In comparison with the races above enumerated, they may be said to be inferior, since they possess the least energy in honey collecting, are less prolific, and not as good defenders of their hives. Under favorable conditions, however, as regards pasturage they may be relied upon for excellent results. They

are, however, spiteful under manipulation, and have the disagreeable habit of running from the combs and dropping in bunches on the ground, likewise of flying from the hive entrance and attacking passers-by. They are more easily discouraged than other bees during slack times as regards honey production, and this is doubtless the main reason for their generally inferior economic value.

WHAT HIVE TO ADOPT.

The suspended Langstroth frame is used more than any other frame among English-speaking bee keepers. It is safe to say that in the United States 500 hives are made and used which are essentially Langstroth in principle to one frame hive of any other kind whatever. In the British Islands, Australia, and New Zealand the proportion of frames on the Langstroth principle in use is probably even greater, scarcely any other frame hives being employed.

The success of American bee culture in the last twenty years was first attributed by European bee keepers to the honey-producing power of the country; but the most intelligent apiarists who have tried the American methods with the Langstroth hive now recognize that success is principally due to the manipulations that it permits. ("The Hive and Honey Bee," revised, 1888, page 145.)

We can predict, and without any fear of mistake, that the principles on which the Langstroth hive is based will be admitted sooner or later by the most progressive bee keepers of the world. ("Revue Internationale d'Apiculture" (Switzerland), September, 1885, edited by Edouard Bertrand.)

There being no patent on the Langstroth hive, and accurately made hives being obtainable at moderate prices from hive factories in various parts of the country, it is taken for granted that the enterprising beginner will adopt a simple form embodying this principle—the loose-fitting, suspended comb frame—as its main feature. The hive should not only be substantially built, but should have accurate bee-spaces and a close-fitting, rain-proof cover or roof. Factory-made hives, as a rule, best meet these requirements, as both lock joints and halved corners can only be made to advantage by machinery, and the expert hive builder understands, of course, the absolute necessity of great accuracy in bee-spaces, as well as the great desirability of good material and work-

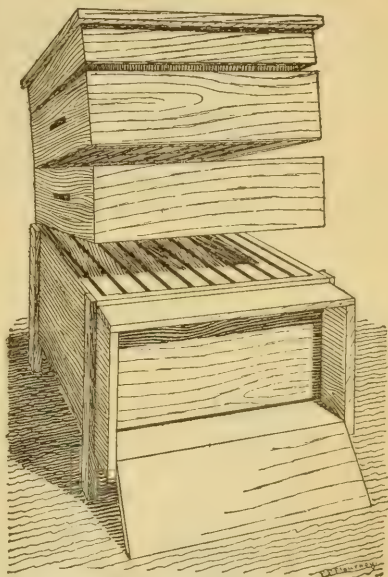


FIG. 4.—Langstroth hive with two half-depth supers for surplus honey.

manship (figs. 4, 5, and 11). Provision should also be made for winter protection. (See pages 39-41.)

For comb honey, hives permitting the insertion in the brood apartment of any number of frames up to eight, or frequently up to ten,

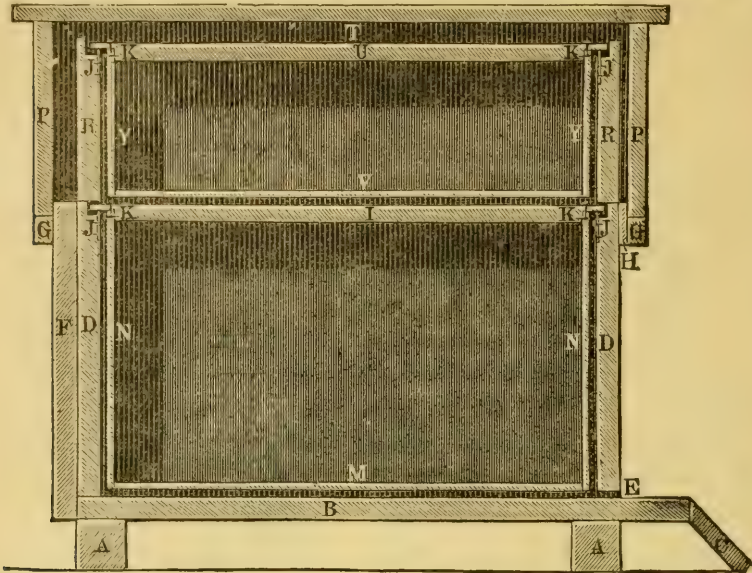


FIG. 5.—The Langstroth hive—Dadant-Quinby form—cross section showing construction.

are most in use. In securing extracted honey, those with ten to twelve frames in each story are preferable, and as many stories, one above the other, are employed as the strength of the colony and a given harvest may require. A construction, therefore, which readily admits of expansion and of contraction, as occasion demands, is desirable.

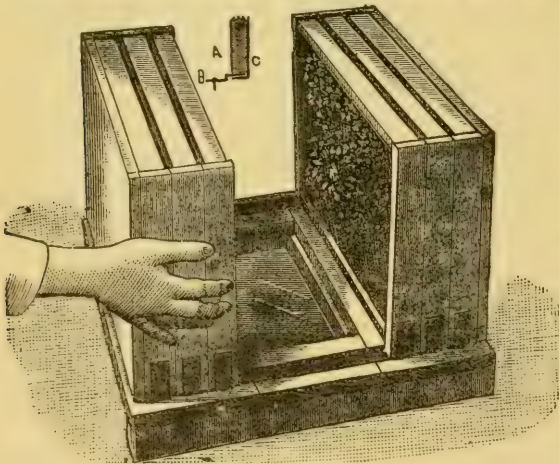


FIG. 6.—Quinby closed-end frames.

which the late M. Quinby gave to the public—the Quinby closed-end frame hive (fig. 6). This hive is used with great success by certain American bee keepers of long experience and whose apiaries are among the largest in the world.

MANAGEMENT IN SWARMING.

NATURAL SWARMING.

When a swarm is seen issuing or in the air, the best thing to do is, in general, simply to wait a bit. The weather is usually rather warm then, and rushing about to get tin pans, dinner gongs, spraying outfits, etc., aside from its disagreeableness, may get one so excited and into such a perspiration as to unfit him to do with the bees that which is likely to be necessary a few minutes later. The bees will probably gather in a clump on a tree or bush near the apiary, and however formidable getting them into the hive may at first seem, nothing will be simpler than shaking them into their new hive, or into a basket or box, from which they may be poured in front of the hive, just as one would pour out a measure of wheat or beans. If any stick to the basket or box, invert it and give a sharp thump with one edge against the ground. If the hive has been standing in the shade so that the boards composing it are not heated, and if it be now well shaded and plenty of ventilation be given above and below, the bees are almost certain to take possession at once and begin work actively.

The securing of swarms can be made, however, even simpler than this by having the colonies placed several feet apart on a smooth lawn or dooryard and clipping one wing of each laying queen so as to prevent her flying. The prime or first swarm from each hive is accompanied by the old queen, and if she be clipped she will of course fall from the alighting board to the ground and may be secured in a cage. The bees will circle about a few times and return. Meanwhile the only thing for the attendant to do is to replace the parent colony by an empty hive. The returning bees will enter the latter and the queen may be allowed to go in with them, the cage being placed with its open end directly against the entrance to insure this. The swarm is thus made to hive itself.

The parent colony removed to a new stand a rod or more away will rarely give a second swarm. But to make certain all queen cells except one may be cut out four or five days after the issuance of the first swarm. At the same time one-third to one-half of the remaining bees of the removed colony may be shaken at the entrance of the hive containing the swarm. This reduces the population of the parent colony greatly, but the loss is soon made good by the young workers emerging daily, and the new queen which will issue from the single queen-cell, spared when cutting out cells, will soon restock the hive with brood. The shaking out of additional bees, coupled with the removal of all queen cells but one, will prevent for the time all further swarming from the given hive, and in most instances end it for the season. The bees thus added to the newly hived swarm, even though too young to enter the field at once as honey gatherers. will nevertheless release

from inside work an equal number of older bees, enabling the latter to go out as field bees.

Each after-swarm (second, third, etc.), it should be borne in mind, is accompanied by one or more unimpregnated queens, and these must not be clipped until they have flown out and mated. The regular deposition of eggs in worker cells may nearly always be regarded as a safe sign that mating has taken place. Eggs will usually be found in such cells within the first ten days of the queen's life. After-swarms may remain in the air, circling about for some time, and they frequently cluster high—a good reason, in addition to the more important fact that their issuance is not consistent with the production of the most surplus honey, for the prevention of all after-swarming.

ARTIFICIAL SWARMING.

Where an increase of colonies is desired, and in case no one can be near the apiary to care for natural swarms with clipped queens, some one of the artificial methods of forming new colonies may be advantageously employed. Natural swarming is, however, to be preferred to a poor system of artificial increase. And no matter which of the artificial methods be adopted, it should be cautiously followed, lest, should unfavorable weather appear suddenly, considerable labor and expense be incurred to prevent disastrous results. It is also of prime importance not to weaken materially the gathering powers of strong colonies just at the opening of the harvest or during its progress; hence, whatever division takes place then must leave the field force—the gatherers—in one mass and in normal condition for work, that is, not discouraged by being queenless, and not overburdened by having brood without a sufficient number of nurse bees to care for it.

Dividing.—A plan which fulfills these conditions is the following: From a populous colony a comb or two with adhering bees and the queen may be taken and placed in a new hive, which, when other frames with starters have been added, is then to be put on the stand of the populous colony from which the combs were taken. The removed colony is to be taken a rod or more from its old stand, so that the flight bees returning from the field will enter the newly established colony. The old colony may be given a laying queen or a mature queen cell a day or two later. This finishes the work in a short time.

Nucleus system.—A better plan, though not so quickly completed, is to take from the populous colony only enough bees and combs to make a fair nucleus on a new stand. A queen is easily and safely introduced into this nucleus, or a queen cell is readily accepted a day or two later. As soon as the young queen has begun egg laying, combs of emerging brood may be added from time to time. These may be obtained from any populous colonies whose tendency to swarm it is desirable to check, the bees adhering to them when they

are removed being in all instances brushed back into their own hive. With fair pasturage the nucleus will soon be able to build combs and may be given frames of comb foundation, or, if the queen be of the current year's raising, frames with narrow strips of foundation as guides may be inserted, since all combs constructed by the nucleus will be composed of worker cells.

Shaken or brushed swarms.—The practice of shaking or brushing bees from the combs of populous colonies into new hives to form artificial or forced swarms has been practiced for many years, to a limited extent in this country and more largely abroad. As early, at least, as 1872 the late C. J. H. Gravenhorst, the editor of *Die Illustrierte Bienenzeitung*, author of *Der Praktische Imker*, and inventor of the Bogenstuelper hive, made artificial swarms in this manner. His articles led the author to experiment in this line and finally to settle upon the plan of placing colonies designed for honey production in pairs in the apiary and, after having brought them up to a suitable strength, shaking or brushing most of the bees of the two into a third hive at the approach of the main honey flow, one queen being allowed to enter the new hive with the shaken swarm. The latter is to be placed on the old stand midway in position between the spots previously occupied by the parent colonies, these having been removed some distance, to be managed thereafter as colonies that have swarmed. The newly shaken swarm is to receive comb-foundation starters in the frames and within a day or two surplus receptacles for honey. In case, however, drawn combs be used in the super, there had better be one or two frames in the brood apartment partly filled with completed comb to hold the first pollen collected. The shaking or brushing should be done toward the latter part of the day and during a time when new honey is coming in, or in the absence of the latter liberal feeding should precede the shaking and be kept up until the start of the honey flow. The shaken swarm is thus brought into quite the same condition as usually obtains in the case of a natural swarm. It is able to send out a strong gathering force at once and will store honey rapidly. The increase of 50 per cent is as large as is consistent with the securing of the best honey yield.

PREVENTION OF SWARMING.

Under the conditions most frequently occurring, however—that is, where it is not practicable to be present at all times during the swarming season, or where the desired number of colonies has been attained—a system of management is advisable which in general contemplates the prevention, in so far as possible, of the issuance of swarms without at the same time interfering with honey storing. The paragraphs following on this subject are taken from the Department publication "The Honey Bee," cited on page 15, footnote:

The most commonly practiced and easily applied preventive measure is that of giving abundant room for storage of honey. This to be effective should be given early in the season, before the bees get fairly into the swarming notion, and the honey should be removed frequently, unless additional empty combs can be given in the case of colonies managed for extracted honey, while those storing in sections should be given additional supers before those already on are completed. With colonies run for comb honey it is not so easy to keep down swarming as in those run for extracted honey and kept supplied with empty comb. Free ventilation and shading of the hives as soon as warm days come will also tend toward prevention. Opening the hives once or twice weekly and destroying all queen cells that have been commenced will check swarming for a time in many instances, and is a plan which seems very thorough and the most plausible of any to beginners. But sometimes swarms issue without waiting to form cells; it is also very difficult to find all cells without shaking the bees from each comb in succession, an operation which, besides consuming much time, is very laborious when supers have to be removed, and greatly disturbs the labors of the bees. If but one cell is overlooked the colony will still swarm. The plan therefore leaves at best much to be desired, and

is in general not worth the effort it costs and can not be depended on.

Dequeening.—The removal of a queen at the opening of a swarming season interferes, of course, with the plans of the bees, and they will then delay swarming until they get a young queen. Then, if the bee keeper destroys all queen cells before the tenth day, swarming will again be checked. But to prevent swarming by keeping colonies queenless longer than a few days at most is to attain a certain desired result at a

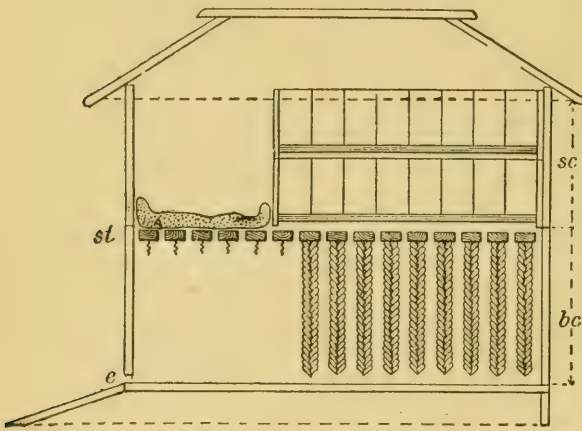


FIG. 7.—The Simmins nonswarming system—single-story hive with supers: *bc*, brood chamber; *sc*, supers; *st*, starters of foundation; *e*, entrance.

disproportionate cost, for the bees will not store diligently when first made queenless, and the whole yield of honey, especially if the flow is extended over some time, or other yields come later in the season, is likely or even nearly sure to be less from such colonies, while the interruption to brood rearing may decimate the colony and prove very disastrous to it. The plan is therefore not to be commended.

Requeening.—Quite the opposite of this, and more efficacious in the prevention of swarming, is the practice of replacing the old queen early in the season with a young one of the same season's raising, produced, perhaps, in the South before it is possible to rear queens in the North. Such queens are not likely to swarm during the first season, and, as they are vigorous layers, the hive will be well populated at all times and thus ready for any harvest. This is important, inasmuch as a flow of honey may come unexpectedly from some plant ordinarily not counted upon; and also, since the conditions essential to the development of the various honey-yielding plants differ greatly, their time and succession of honey yield will also differ with the season the same as the quantity may vary. Young queens are also safest to head the colonies for the winter. The plan is conducive to the highest prosperity

of the colonies, and is consistent with the securing of the largest average yield of honey, since, besides giving them vigorous layers, it generally keeps the population together in powerful colonies. It is therefore to be commended on all accounts as being in line with the most progressive management, without at the same time interfering with the application of other preventive measures.

Space near entrances.—Arranging frames with starters, or combs merely begun, between the brood nest and the flight hole of the hive, while the bees are given storing space above or back of the brood nest (figs. 7 and 8), is a plan strongly recommended by Mr. Samuel Simmins, of England, and which has come to be known as "the Simmins nonswarming method," some features of it and the combination into a well-defined method having been original with him. It is an excellent preventive measure, though not invariably successful, even when the distinctive features brought forward prominently by Mr. Simmins—empty space between the brood combs and entrance, together with the employment of drawn combs in the supers—are supplemented by other measures already mentioned; but when, in addition to the space between the brood and the flight hole, the precaution be taken to get supers on in time, to ventilate the hive well, and to keep queens not over two years old, swarming will be very limited. If to these precautions be added that of substituting for the old queens young ones of the current season's raising, before swarming has begun, practical immunity from swarming is generally insured.

Selection in breeding.—Some races of bees show greater inclination than others toward swarming, and the same difference can be noted between individual colonies of a given race; therefore, whatever methods be adopted to prevent or limit increase, no doubt the constant selection of those queens to breed from whose workers show the least tendency toward swarming

would in time greatly reduce this disposition. Indeed, it is perfectly consistent to believe that persistent effort, coupled with rigid and intelligent selection, will eventually result in a strain of bees quite as much entitled to be termed nonswarming as certain breeds of fowls which have been produced by artificial selection are to be called nonsitters. These terms are of course only relative, being merely indicative of the possession of a certain disposition in a less degree than that shown by others of the same species. It might never be possible to change the nature of our honeybees so completely that they would never swarm under any circumstances, and even if possible it would take a long period, so strongly implanted seems this instinct. But to modify it is within the reach of any intelligent breeder who will persistently make the effort. Such work should be undertaken in experimental apiaries where its continuance when a single point has been gained will not be affected by the changes of individual fortunes.

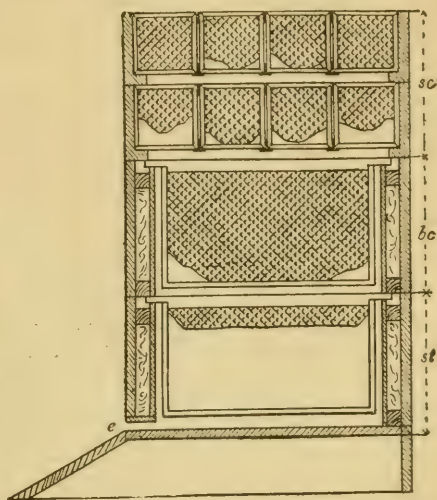


FIG. 8.—The Simmins nonswarming system—double-story hive with supers: *bc*, brood chamber; *sc*, supers; *st*, chamber with starters of comb foundation; *e*, entrance.

SPECIAL CROPS FOR HONEY ALONE NOT PROFITABLE.

With a small apiary, planting for honey alone certainly can not be made profitable. Small plats of honey-producing plants are valuable mainly because they afford an opportunity of observing when and under what circumstances the bees work on certain blossoms, and for the purpose of determining what might be depended upon to fill a gap in the honey resources of a given locality whenever the size of the apiary might make this a consideration of some importance. Even with a large apiary probably no case exists in which, in the present condition of the subject, planting for honey alone would prove profitable. But when selecting crops for cultivation for other purposes, or shrubs and trees for planting, the bee keeper should of course choose such as will also furnish honey at a time when pasturage for his bees would otherwise be wanting.

As complete a list as possible should be made of the plants and trees visited by honeybees, and notes should be added as to period of blossoming, importance of yield, whether honey or pollen or both of these are collected, quality of the product, etc. If gaps occur during which no natural forage abounds for the bees, some crop can usually be selected which will fill the interval, and, while supplying a continuous succession of honey-yielding blossoms for the bees, will give in addition a yield of fruit, grain, or forage from the same land. The novice is warned, however, not to expect too much from a small area. He must remember that as the bees commonly go $2\frac{1}{2}$ to 3 miles in all directions from the apiary, they thus range over an area of 12,000 to 18,000 acres, and if but 1 square foot in 100 produces a honey-yielding plant they still have 120 to 180 acres of pasturage, and quite likely the equivalent of 30 to 40 acres may be in bloom at one time within range of the bees. A few acres more or less at such a time will therefore not make a great deal of difference.

But if coming between the principal crops—especially if the bees, as is often the case, would otherwise have no pasturage at all—the area provided for them may be of greater relative importance than the larger area of natural pasturage; for it frequently occurs that the smaller part only of the honey produced by the field over which the bees of an apiary range can be collected by them before it is washed out by rains, or the liquid portion is evaporated and the blossoms withered, while a smaller area may be more assiduously visited, and, the nectar being gathered as fast as secreted, a greater yield per acre may result.

It is further of some importance to fill in such a gap with something to keep the bees busy, instead of letting them spend their time trying to rob one another; and, what is probably even more important, the pasturage thus furnished will keep up brood rearing and comb building and assist materially in preparing the colonies for the succeeding honey flow.

There are many plants and trees of economic value, in addition to their production of honey, which may be utilized in one portion or another of the United States in the manner indicated. Adaptability to climate and soil, the periods of honey dearth to be filled in, markets for the crop produced, etc., must all come in to influence the choice. The following list includes the more important plants of economic value in this country which are good honey and pollen yielders. Most of those named are adapted to a considerable portion of the Union. Except in the case of plants restricted to the South, the dates given are applicable, in the main, to middle latitudes.

ECONOMIC PLANTS AND TREES FOR CULTIVATION FOR HONEY AND POLLEN.

Filbert bushes, useful for wind-breaks and for their nuts, yield pollen in February and March.

Rape can be grown successfully in the North for pasturage, for green manuring, or for seed, and when permitted to blossom yields considerable pollen and honey. Winter varieties are sown late in the summer or early in the autumn, and blossom in April or May following. This early yield forms an excellent stimulus to brood rearing. Summer or bird rape, grown chiefly for its seed, blossoms about a month after sowing. It does best during the cooler months of the growing season.

Russian or hairy vetch is a hardy leguminous plant of great value for forage and use in green manuring. The blossoms appear early in the season, and, where there is any lack in early pollen, especially in northern and cool regions, this vetch will be found of great value to the bees.

Fruit blossoms—apricot, peach, pear, plum, cherry, apple, currant, and gooseberry—yield pollen and honey in abundance during April or May; strawberry and blackberry are sometimes visited freely by bees, but are generally far less important than the others mentioned. Colonies that have wintered well often gather during apple bloom 12 to 15 pounds of surplus honey of fine quality. The raspberry secretes a large amount of nectar of superb quality, and coming in May or June, thus later than the other fruit blossoms and when the colonies are stronger and the weather is more settled, full advantage can nearly always be taken of this yield. Grape and persimmon blossom also in June; the latter is an excellent source. In subtropical portions of the country orange and lemon trees yield fine honey in March and April, and the cultivation of the banana has added a profuse honey yielder which puts forth successive blossoms all through the summer months.

Locust, tulip tree ("poplar," or whitewood), and horse-chestnut, useful for shade, ornament, and timber, are all fine honey producers in May. The locust yields light-colored, clear honey of fine quality, the others amber-colored honey of good body and fair flavor.

Clovers.—Crimson, blossoming in April or May, yields fine, light-colored honey; white, alsike, and mammoth or medium, blossoming in May, June, and July, give honey of excellent quality and rich yellow color.

Mustard grown for seed flowers from June to August. The honey is somewhat acrid and crystallizes soon, yet the plant, where abundant, is of much importance to the bees and the bee keeper in case other forage is scant at the time.

Asparagus blossoms are much visited by bees in June and July.

Esparecet, or **sainfoin**, yields in May and June fine honey, almost as clear as spring water. It is a perennial leguminous plant, rather hardy, an excellent forage crop, and particularly valuable for milch cows. It succeeds best on a limestone soil or when lime is used as a fertilizer, and is itself an excellent green manure for soils deficient in nitrogen and phosphoric acid.

Sulla, or **sulla clover**, a perennial plant, closely related to esparecet or sainfoin, succeeds, like the latter, best upon limestone soil or when fertilized with lime. It yields a splendid quality of honey from beautiful pink blossoms, which continue during May and June. The plant is an excellent soil fertilizer and of great value in connection with the feeding of stock, particularly dairy animals. It is, however, much less hardy than esparecet, and success with it can therefore hardly be looked for above the latitude of North Carolina and Arkansas. When the qualities and requirements of this plant were brought by the writer to the notice of a prominent scientific agriculturist of the South, this gentleman suggested as very probable that the black belt of Alabama, Mississippi, Louisiana, and Texas would be well adapted to it, the lands of this region being exceedingly strong in lime. In portions of southern Europe sulla clover is a most important forage crop for farm stock as well as for honey bees.

Serradella is an annual leguminous plant which will grow on sandy land, and which yields, besides good forage, clear honey of good quality in June and July.

Chestnut, valuable for timber, ornament, shade, and nuts, yields honey and pollen in June or July.

Linden, **sourwood**, and **catalpa**, fine shade, ornamental, and timber trees, yield great quantities of first quality honey in June and July.

Cotton.—In the South cotton blossoms, appearing as they do in succession during the whole summer, often yield considerable honey. It would appear, however, that when the plants are very rank in growth the blossoms—being correspondingly large—are too deep for the bees to reach the nectar.

Chicory, raised for salad and for its roots, is, whenever permitted to blossom, eagerly visited for honey in July and August.

Sweet, medicinal, and pot herbs, such as marjoram, savory, lavender,

catnip, balm, sage, thyme, etc., when allowed to blossom, nearly all yield honey in June, July, or August. Where fields of them are grown for the seed the honey yield may be considerable from this source.

Alfalfa furnishes in the West a large amount of very fine honey during June and July. Its importance there as a forage crop is well known, but how far eastward its cultivation may be profitably extended is still a question, and even should it prove of value in the East as a forage plant, its honey-producing qualities there would be still uncertain.

Parsnips, when left for seed, blossom freely from June to August, inclusive, and are much frequented by honey bees.

Peppermint, raised for its foliage, from which oil is distilled, is most frequently cut before the bees derive much benefit from it, but whenever allowed to blossom it is eagerly sought after by them, and yields honey freely during July and August.

Bokhara, or **sweet clover**, is in some sections of the country considered a valuable forage crop. Animals can be taught to like it, and it is very valuable as a restorer of exhausted lime soils, while in regions lacking in bee pasturage during the summer months it is a very important addition. It withstands drought remarkably well and yields a large quantity of fine honey.

Cucumber, **squash**, **pumpkin**, and **melon** blossoms furnish honey and some pollen to the bees in July and August.

Eucalypti, valuable for their timber and as ornaments to lawn and roadside, are quick-growing trees adapted to the southern portions of the United States. They yield much honey between July and October.

The **carob tree**, whose cultivation has been commenced in the Southwest, is an excellent honey yielder in late summer. It is an ornamental tree and gives, in addition to honey, another valuable product—the carob bean of commerce.

Sacaline, a forage and ornamental plant of recent introduction, is a great favorite with bees. It blossoms profusely during August, is a hardy perennial, and thrives in wet and also fairly in dry situations, withstanding the ordinary summer drought of the Eastern States because of its deeply penetrating roots.

Buckwheat is an important honey and pollen producer. Its blossoms appear about four weeks after the seed is sown, hence it may be made to fill in a summer dearth of honey plants.

HOW TO OBTAIN SURPLUS HONEY AND WAX.

Good wintering, followed by careful conservation of the natural warmth of the colony, the presence of a prolific queen—preferably a young one—with abundant stores for brood rearing, are, together with the prevention, in so far as possible, of swarming, the prime conditions necessary to bring a colony of bees to the chief honey flow in shape to

enable it to take full advantage of the harvest. In addition it is only necessary to adjust the surplus honey receptacles in time, making the space given proportionate to the strength of the colony, and, while continuing to prevent as far as possible the issuance of swarms, to remove the accumulated honey fast enough to give abundant storage room.

EXTRACTED HONEY.

To secure extracted honey, the requisite number of combs may be in one long hive, or in stories one above another. Preference is most generally given to the latter plan. The brood apartment is made in this case to hold eight to twelve Langstroth frames, and a second, and sometimes a third or even a fourth story, may be added temporarily. These added stories may be for full-depth frames, or, for convenience in handling and in order to be able to control more closely the amount of space given, they may be half the usual depth, and but one of the half-depth stories added at a time. If numerous sets of combs are at hand, or if it is desirable to have others built, additional stories are put on as fast as the combs already occupied by the bees are filled. Before removing the filled combs time should be allowed the bees to

ripen and cap the honey; hence enough combs are necessary to give the bees storage room while they are capping others. The honey



FIG. 9.—Quinby uncapping knife.

in combs that are quite or nearly sealed over may be considered sufficiently ripened to be removed from the hive.

It should also be taken promptly, in order to keep the various grades or kinds separate. However, when the combs of a given super are completely filled and sealed it may be marked and left on the hive if more convenient to be extracted later.

The cells are uncapped by means of a sharp knife, made especially for this purpose (fig. 9), and the combs are then made to revolve rapidly in the honey extractor (fig. 10). The centrifugal force exerted on the honey throws it out, leaving the comb cells uninjured, or so slightly injured that they are wholly repaired within an hour or so after the return of the comb to the hive. The chief advantages of this method of harvesting over that of crushing the combs are at once apparent when it is known that each pound of comb saved represents several pounds of honey (consumed in its construction), and may, with care be used over almost indefinitely in securing surplus honey. Furthermore, extracted honey is of much finer quality than that obtained by crushing the combs and straining out the liquid part, since it is free from crushed bees, larvæ, pollen or "bee bread," etc., which not only render strained honey dark and strong in flavor, but also make it liable to fermentation and souring.

The extracted honey is run into open buckets or tanks and left, covered with cheese cloth, to stand a week or so in a dry, warm room not frequented by ants. It should be skimmed each day until perfectly clear, and is then ready to be put into cans or barrels for marketing, or to be stored in a dry place. Square tin cans, each made to hold 60 pounds of extracted honey, are sold by dealers in apiarian supplies. This style of package is a convenient one to transport, and is also acceptable to dealers. Wooden shipping cases are usually constructed so as to hold two of these cans. Barrels and kegs may be used, especially for the cheaper grades of honey used chiefly in the manufacture of other articles. They should be dry, made of well-seasoned, sound wood, and the hoops driven tight and secured, as well-ripened honey readily absorbs moisture from wood, causing shrinkage and leakage. They should also be coated inside with beeswax or paraffin. This is easily done by warming the barrels and then pouring in a gallon or two of hot wax or paraffin, and, after having driven in the bungs tightly, rolling the barrels about a few times and turning them on end. The work should be done quickly and the liquid not adhering to the inner surfaces poured out at once, in order to leave but a thin coating inside.

The surplus combs are to be removed at the close of the season and hung an inch or so apart on racks placed in a dry, airy room, where no artificial heat is felt. Mice, if permitted to reach them, will do considerable damage by gnawing away the cells containing pollen or those in which

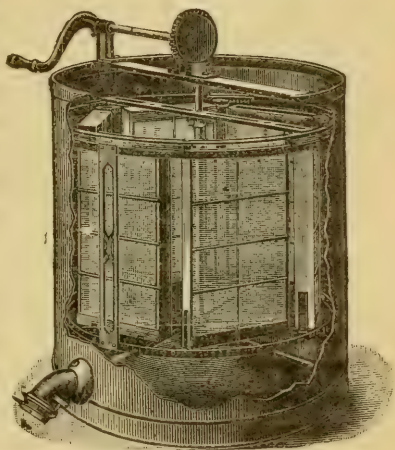


FIG. 10.—Automatic reversible honey extractor.

bees have been bred, and which therefore contain larval and pupal skins. Moth larvæ are not likely to trouble them until the following spring, but upon the appearance of milder weather their ravages will begin, and if the combs can not be placed under the care of the bees at once they must be fumigated with burning sulphur or with bisulphide of carbon.

COMB HONEY.

The main difference to be observed in preparing colonies for the production of comb honey, instead of extracted, is in the adjustment of the brood apartment at the time the supers are added. After the colony has been bred up to the greatest possible strength, the brood apartment should be so regulated in size, when the honey flow begins and the supers are added, as to crowd many of the bees out and into the supers placed above.

On each hive a super is placed (fig. 11) holding 24 to 48 sections, each section supplied with a strip or a full sheet of very thin foundation. It is best not to give too much space at once, as considerable warmth is necessary to enable the bees to draw out foundation or to

build comb. A single set of sections is usually sufficient at a time. When the honey is designed for home use or for a local market, half-depth frames are sometimes used, the same as those often used above the brood nests when colonies are run for extracted honey, but for the general market pound sections (fig. 12) are better adapted.

It is the practice of many to have nice white comb partially drawn out before the main honey flow begins, or even the season before, feeding the colonies, if necessary, to secure this; and, when the honey yield be-

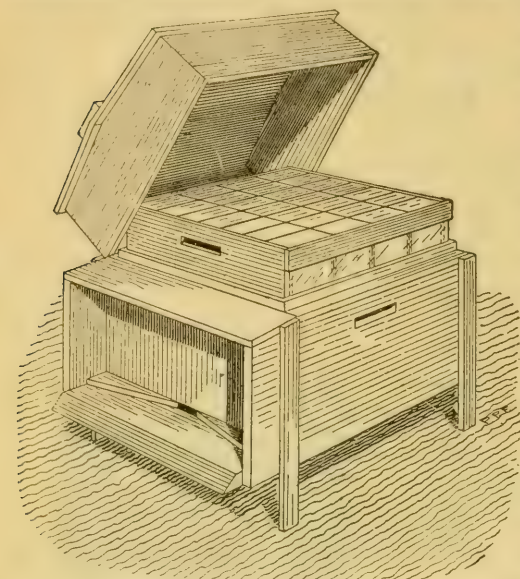


FIG. 11.—Langstroth hive—super above holding 28 sections for comb honey.

gins, to supply sets of sections with these combs having cells deep enough for the bees to begin storing in as soon as any honey is collected. Earlier work in the sections is thus secured, and this, as is well known, is an important point in the prevention of swarming. Mr. Samuel Simmins, of England, has long contended for this use of partially drawn combs, and though it forms a feature of his system for the prevention of swarming it has been too often overlooked. Comb foundation is now manufactured with extra thin septum or base and with the beginnings of the cells marked out by somewhat thicker walls which the bees immediately thin down, using the extra wax in deepening the cells. This is not artificial comb, but a thin sheet of wax having the bases of the cells outlined on it. Complete artificial combs have never been used in a commercial way, although there exists a widespread belief to this effect, which is founded on extravagant claims that have appeared from time to time in newspaper articles.

If the brood apartment has been much contracted when the supers

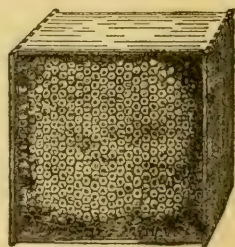


FIG. 12.—Comb honey stored in pound section—size $4\frac{1}{2}$ by $4\frac{1}{2}$ inches.

were added, the queen may go into the sections and deposit eggs unless prevented by the insertion of a queen excluder (fig. 13). This, merely a sheet of zinc with perforations which permit workers, but not the queen, to pass, is placed between the brood apartment and the supers. The great inconvenience of having brood in some of the sections is thereby prevented. When the honey in the sections has been nearly capped over, the super may be lifted up and another added between it and the brood apartment. Or, should the strength of the colony not be sufficient, or the harvest not abundant enough to warrant the giving of so much space, the sections which are completely finished may be removed and the partly finished ones used as "bait sections" to encourage work in another set of sections on this hive or in new supers elsewhere. The objections to the removal of sections one by one, and brushing the bees from them, are (1) the time it takes, and (2) the danger that the bees when disturbed, and especially if smoked, will bite open the capping and begin the removal of the honey, thus injuring the appearance of the completed sections.

A recent valuable invention, the bee escape (fig. 3), the use of which is explained on pages 15 and 16, when placed between the super and the brood nest, permits the bees then above the escape to go down into the brood apartment, but does not permit their reentering the super. If inserted twelve to twenty-four hours before the sections are to be removed, the latter will be found free from bees at the time of removal, provided all brood has been kept out of the supers.

Grading and shipping comb honey.—Before marketing the honey it should be carefully graded, and all propolis ("bee-glue"), if there be any, scraped from the edges of the sections. In grading for the city markets the following rules are, in the main, observed. They were adopted by the North American Bee-Keepers' Association at its twenty-third annual convention, held in Washington, D. C., in December, 1892, and are copied from the official report of that meeting:

Fancy.—All sections to be well filled; combs straight, of even thickness, and firmly attached to all four sides; both wood and comb unsoiled by travel stain or otherwise; all cells sealed except the row of cells next to the wood.

No. 1.—All sections well filled, but with combs crooked or uneven, detached at the bottom, or with but few cells unsealed; both wood and comb unsoiled by travel stain or otherwise.

In addition to the above, honey is to be classified, according to color, into light, amber, and dark. For instance, there will be "fancy light," "fancy amber," and "fancy dark," "No. 1 light," "No. 1 amber," and "No. 1 dark."

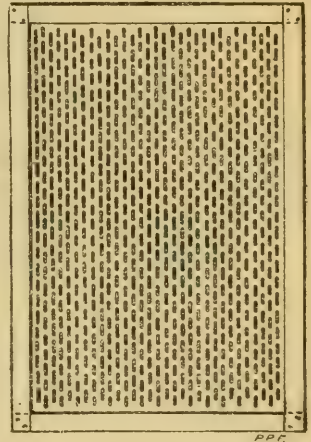


FIG. 13.—Perforated zinc queen-excluder.

The sections, after grading and scraping, are to be placed in clean shipping cases having glass in one or both ends (fig. 14). Several of these may be placed in a single crate for shipment. To prevent breaking down of the combs it is best to put straw in the bottom of the crate for the shipping cases to rest on, and the crates should be so placed as to keep the combs in a perpendicular position. The crates are also likely to be kept right side up if convenient handles are attached to the sides—preferably strips with the ends projecting beyond the corners. Care in handling will generally be given if the glass in the shipping cases shows.

Owing to the appearance of statements of a sensational character to the effect that complete honey combs are manufactured by machinery and filled with sweets lower in price than honey (glucose, cane sugar, or mixtures of these), then sealed over and sold in the market as genuine honey, a strong suspicion exists regarding the comb honey commonly offered for sale. Wide circulation has been given to these

wild stories by sensational newspaper writers, and even monthly periodicals, usually far more discriminating and accurate, have repeated them. Some writers have even tried to locate the "comb-honey factories" in given cities, but investigation has always shown that the locations were myth-

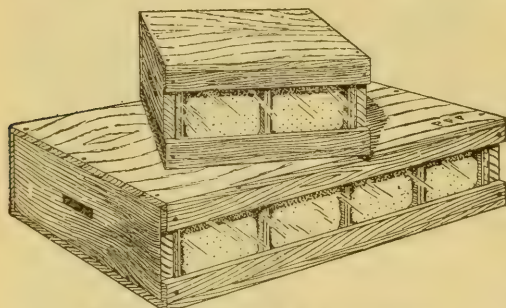


FIG. 14.—Shipping cases for comb honey.

ical. The forfeit of \$1,000 which a reputable firm has had standing for fifteen years past for a pound of manufactured comb honey of a nature to deceive the buyer still remains unclaimed.

The National Bee-Keepers' Association, at its annual convention held in St. Louis in 1904, offered also a like forfeit of \$1,000 for satisfactory proof of the existence of such a thing as manufactured comb honey. But no claimant has come forward, notwithstanding the \$2,000 which awaits his proof. The fact is, there is no truth in the "yarn," and no one has thus far shown the thing possible. The comb honey in the markets is pure and wholesome—a healthful and nourishing sweet, easier to digest than cane sugar or any of the sirups so commonly sold. It is worth a place on the tables of all who can afford to use it.

PRODUCTION OF WAX.

No method has yet been brought forward which will enable one, at the present relative prices of honey and wax, to turn the whole working force of the bees, or even the greater part of it, into the produc-

tion of wax instead of honey; in fact, the small amount of wax produced incidentally in apiaries managed for extracted or for section honey is usually turned into honey the following season; that is, it is made into comb foundation, which is then employed in the same hives to increase their yield of marketable honey. It is even the case that in most apiaries managed on approved modern methods more pounds of foundation are employed than wax produced; hence less progressive bee keepers—those who adhere to the use of box hives and who can not therefore utilize comb foundation—are called upon for their wax product. As each pound of wax represents several pounds of honey, all cappings removed when preparing combs for the extractor, all scrapings and trimmings and bits of drone comb, are to be saved and rendered into wax. This is best done in the solar wax extractor (fig.

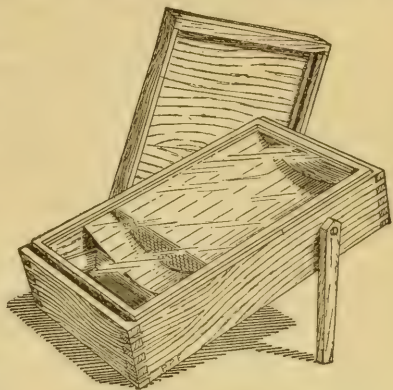


FIG. 15.—Solar wax-extractor.

15), the essential parts of which are a metal tank with wire-cloth strainer and a glass cover, the latter generally made double. The bottom of the metal tank is strewn with pieces of comb, the glass cover adjusted, and the whole exposed to the direct rays of the sun. A superior quality of wax filters through the strainer.

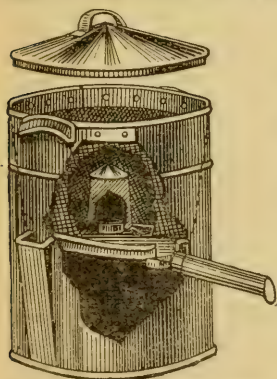


FIG. 16.—Steam wax-extractor.

Another method is to inclose the cappings or combs to be rendered in a coarse sack and weight this down in a tin boiler partly filled with rain water or soft spring water and boil slowly until little or no more wax can be pressed out of the material in the sack. Melting in an iron receptacle makes the wax dark colored. A special utensil made of tin, for use as a wax-extractor (fig. 16) over boiling water, can also be had. The bits of comb are placed in this, in an inside can having fine perforations, through which the steam from below enters and melts out the wax, which drips

from a spout into another receptacle partly filled with water, from the surface of which the cake of wax may be removed when cold.

THE WINTERING OF BEES.

How to bring bees successfully through the winter in the colder portions of the United States is a problem which gives anxiety to all who are about to attempt it for the first time in those sections, and

even many who have kept bees for years still find it their greatest difficulty. It may happen occasionally that a queen, apparently young and vigorous in the autumn, will die during the winter, when a young one can not be reared, and as a result the colony will dwindle away. Such losses are, however, rare, and, aside from the possible results of fire, flood, or violent storms, are about the only ones which can not be avoided by careful attention to right methods in wintering. Insufficient or poor winter stores, hives faulty in construction, lack of protection from cold and dampness, too much or too little ventilation, too great a proportion of old bees or too great a proportion of young ones, overmanipulation late in the season, etc., are the most important and most easily detected causes of loss in wintering bees. In some instances colonies supposed to have been placed in the same condition under which others have wintered well become diseased and die or dwindle away without prominent signs of disease. It is evident, however, that some condition existed in one case which was not present in the other, or that, in spite of some unfavorable condition, the favorable ones combined, in the first instance, to render the wintering successful.

In the South wintering in the open air on the summer stands is the only method followed, while in the colder portions of the country, although with proper precautions bees may be wintered successfully in the open air, many prefer to house them in special repositories built with double walls, or to place them in darkened cellars, or in clamps. Indoor wintering should be confined to regions where there are several weeks, at least, of continued severe weather. When all conditions are right, consumption of honey will be less indoors and loss of bee life less than with the methods usually practiced in outdoor wintering. Under proper conditions, however, especially when abundant protection has been given, colonies out of doors will consume no more food nor meet with greater losses in numbers than those wintered under favorable conditions indoors. In wintering indoors certain essential conditions are, in a measure, beyond the control of the bee keeper, hence must be left to chance, and certain other conditions and emergencies liable to arise, though easily understood and met by the man of experience in this direction, are yet very likely to be overlooked by the novice or to be puzzling and disastrous to him. For these reasons it is safer for him to keep closer to the natural method at first and try outdoor wintering.

In wintering out of doors the conditions within the control of the bee keeper are more readily perceived and easier to meet, and though the original work of preparation for good wintering out of doors is greater per colony, yet the work during the winter itself and the following spring is likely to be less; moreover, the feeling of greater security, as well as the greater certainty of finding the colonies in good condition to begin gathering in the spring, are points well worthy of

consideration. In other words, indoor wintering should be left to such experienced bee keepers as may prefer it and are located in cold climates, while novices, wherever located, should first endeavor to meet the requirements of successful outdoor wintering; that is, to prepare the colonies so that Nature, whatever her mood as regards the weather, will bring her tiny charges safely through the perils and vicissitudes of the winter months.

GENERAL CONSIDERATIONS.

Whatever method be followed in wintering, certain conditions regarding the colony itself are plainly essential: First, it should have a good queen; second, a fair-sized cluster of healthy bees, neither too old nor too young; third, a plentiful supply of good food. The first of these conditions may be counted as fulfilled if the queen at the head of the colony is not more than two years old, is still active, and has always kept her colony populous; yet a younger queen—even one of the current season's rearing, and thus but a few weeks or months old—is if raised under favorable conditions, much to be preferred. The second point is met if brood rearing has been continued without serious interruption during the latter part of the summer and the cluster of bees occupies, on a cool day in autumn, six to eight or more spaces between the combs, or forms a compact cluster 8 or 10 inches in diameter. Young bees, if not well protected by older ones, succumb readily to the cold, while quite old bees die early in the spring, and others, which emerged late in the summer or autumn preceding, are needed to replace them. The third essential—good food—is secured if the hive is liberally supplied with well-ripened honey from any source whatever, or with fairly thick sirup, made from white cane sugar, which was fed early enough to enable the bees to seal it over before they ceased flying. The sirup is prepared by dissolving 3 pounds of granulated sugar in 1 quart of boiling water and adding to this 1 pound of pure extracted honey. Twenty to 25 pounds for outdoor wintering in the South, up to 30 or 40 pounds in the North, when wintered outside with but slight protection—or, if wintered indoors, about 20 pounds—may be considered a fair supply of winter food. A smaller amount should not be trusted except in case much greater protection be furnished against the effects of severe weather than is usually given. A greater amount of stores will do no harm if properly arranged over and about the center of the cluster, or, in case the combs are narrow, wholly above the cluster. In many instances it will be a benefit by equalizing in a measure the temperature in the hive, as well as by giving to the bees greater confidence in extending the brood nest in early spring.

INDOOR WINTERING.

A dry, dark cellar or special repository built in a sidehill or with double, filled walls, like those of an ice house, may be utilized for wintering bees in extremely cold climates. It should be so built that a temperature of 42° to 45° F. (the air being fairly dry in the cellar) can be maintained during the greater part of the winter. To this end it should be well drained, furnished with adjustable ventilators, and covered all over with earth, except the entrance, where close-fitting doors, preferably three of them, should open in succession, so as to separate the main room from the outside by a double entry way. The colonies, supplied with good queens, plenty of bees, 20 to 25 pounds of stores each, and with chaff cushions placed over the frames, are carried in shortly before snow and severe freezing weather come.

Any repository which is damp or one whose temperature falls below freezing or remains long below 38° F. is not a suitable place in which to winter bees. When in repositories, the bees have no opportunity for a cleansing flight, nor do they, when the temperature rises outside, always warm up sufficiently to enable the cluster to move from combs from which the stores have been exhausted to full ones; hence in a cold repository they may possibly starve with plenty of food in the hive. As a rule, colonies would be better off out of doors on their summer stands than in such places.

OUTDOOR WINTERING.

Cold and dampness are the great winter enemies of bee life. A single bee can withstand very little cold, but a good cluster, if all other conditions are favorable, can defy the most rigorous winters of our coldest States. But if not thoroughly dry, even a moderate degree of cold is always injurious, if not absolutely fatal. Dampness in winter is therefore the most dangerous element with which the bee keeper has to contend. The matter would, of course, be quite simple if only that dampness which might come from the outside were to be considered, but when the air of the hive, somewhat warmed by the bees and more or less charged with the moisture of respiration, comes in contact with hive walls or comb surfaces made cold by outside air, condensation takes place, and the moisture trickles over the cold surfaces and cluster of bees, saturating the air about them or even drenching them, unless by forming a very compact cluster they are able to prevent it from penetrating, or by greater activity to raise the temperature sufficiently to evaporate the surplus moisture, or at least that portion near them. But this greater activity is, of course, at the expense of muscular power and requires the consumption of nitrogenous as well as carbonaceous food. Increased cold or its long continuance greatly aggravates conditions.

Nature has provided that the accumulation of waste products in the body of the bee during its winter confinement should be small under normal conditions, but unusual consumption of food, especially of a highly nitrogenous nature like pollen, necessitates a cleansing flight, or diarrheal difficulties ensue, combs and hives are soiled, the air of the hive becomes polluted, and at last the individual bees become too weak to generate proper warmth or drive off the surplus moisture which then invades the cluster and brings death to the colony; or, what is more frequently the case, a cold snap destroys the last remnant of the colony, which has been reduced by constant loss of bees impelled by disease to leave the cluster or even to venture out for a cleansing flight when snows and great cold prevail.

The problem then is: *To retain the warmth generated by the bees, which is necessary to their well-being, and at the same time to prevent the accumulation of moisture in the hive.* A simple opening at the top of the hive would permit much of the moisture to pass off, but of course heat would escape with it and a draft would be produced. Absorbent material about the cluster creates, without free ventilation, damp surroundings, and again the temperature is lowered. It is only necessary, however, to surround the bees with sufficient material to protect them fully against the greatest cold likely to occur, and to take care also that this enveloping material is of such a nature and so disposed as to permit the free passage of the moisture which would otherwise collect in the interior of the hive, and to permit the escape into the surrounding atmosphere of such moisture as enters this material from within. This packing should also be fully protected from outside moisture.

South of Virginia, Kentucky, and Kansas single-walled hives may be employed in most localities with good success in outdoor wintering. On the approach of the cool or the rainy season a close-fitting quilt should be laid over the frames and several folded newspapers pressed down on this, or a cushion filled with dry chaff or some other soft material may be used instead of paper. The cover or roof should be absolutely rain proof, yet between this cover and the cushion or papers should be several inches of space with free circulation of air. In order to permit this ventilation above the top packing, the cover should not rest upon the cap or upper story all of the way around, or if it does, an auger hole in each end, protected by wire cloth against the entrance of mice, should give free passage to the air. In the

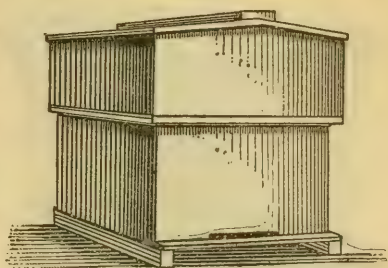


FIG. 17.—Double-walled hive adapted to outdoor wintering as well as summer use below 40° north latitude in the United States. Thickness of each wall, $\frac{3}{4}$ inch, space between walls, 2 inches, packed with dry chaff or ground cork.

more northern portion of the section referred to some further protection is advisable (fig. 17), and is really necessary in the mountainous parts of the same territory if the best results are to be obtained. Farther north, and especially in the cold Northwest, much greater protection becomes an absolute necessity. Quilts with newspapers or thin packing above do not alone suffice. The side walls of the hive may be made of pressed straw (fig. 18). These, with top packing, if kept dry outside, are excellent for outdoor wintering, even in climates so cold that ordinary wooden hives do not afford sufficient protection.

In the severest climates, however, still greater protection on all sides of the colony is needed, and packing with chaff or other soft material is decidedly the best plan. The thickness of this surrounding packing should be from 2 inches to 8 or 10 inches for single colonies, according to the severity of the climate, but if four or more colonies are grouped for the winter, so as to make the natural warmth generated mutually advantageous, somewhat less packing will be sufficient. A most

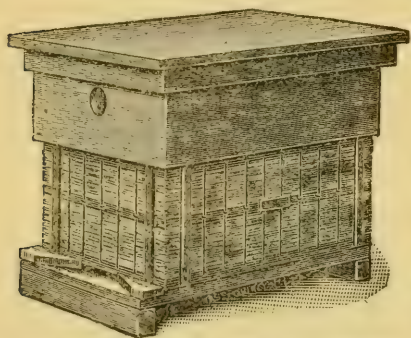


FIG. 18.—The American straw hive (Langstroth principle) of Hayek Brothers.

important point is to have the soft warmth-retaining packing come in close contact with the edges of the combs, and above all *not to have a hive wall, either thick or thin, between this material and the bees*. A good plan is to construct an open framework or skeleton hive of laths, cover it with sacking, or, preferably, some less fuzzy cloth which the bees will not gnaw, and after placing it in an outer wooden case large enough every way to admit of the

necessary packing about the colony, to fill in on all sides with some dry, porous material (fig. 19). If the frames are shallow, like the Langstroth, it is better to construct the inner case so as to place them on end, and thus give a deeper comb for the winter. Layers of newspapers may come next outside the cloth covering of the framework. Wheat chaff answers well to complete the packing. Wool is to be preferred, but is of course too expensive unless a waste product. Ground cork, waste flax, hemp, sawdust, etc., in fact, any fine porous material, if thoroughly dry, may be used.

A board passageway 3 or 4 inches wide and three-eighths of an inch high should connect this inner apartment and the flight hole of the outer case, thus affording an exit for the bees whenever the weather may permit them to fly. When these preparations have been completed, the hive is ready for the combs, which, with adhering bees, are taken from the summer hive and inserted in the winter hive. A quilt is then laid on the frames and the top packing put on. This, for con-

venience, may be held in a cloth-bottomed tray. It is quite important, as already mentioned, that air be allowed to circulate freely above the packing. The outside case must be quite rain-proof or else wholly protected from the rain by a roof.

All other necessary conditions having been complied with shortly after the gathering season closed, the combs may be lifted from the summer hives and placed in these specially arranged winter cases before cold weather wholly stops the bees from flying out. Thus prepared for the winter the colonies will need but slight attention from October until March, or, in the North, even later, and the losses will be limited to the small percentage of cases due to failure of apparently good queens.

THE RISK OF LOSS THROUGH DISEASE AND ENEMIES.

Winter losses through disease superinduced by unfavorable surroundings which it is within the power of the bee keeper to avoid have already been considered. But one other very serious disease has been widespread.

FOUL BROOD OR BACILLUS OF THE HIVE.

This is a highly contagious affection which, as it mainly affects the developing brood in the cells, is commonly known as "foul brood." It is due to a microbe (*Bacillus alvei*) whose spores are easily transported from hive to hive by the bees themselves, by the operator, in honey, or in combs changed from one hive to another. Once established in an apiary, it usually spreads, unless speedily and energetically checked, until all of the colonies in the neighborhood are ruined and even exterminated. The most apparent symptoms are the turning black of larvæ in open cells, many sealed cells with sunken caps, frequently broken in and containing dead larvæ or pupæ in a putrid condition, brown or coffee-colored, jelly-like or ropy in consistency, and giving off an offensive odor. The disease, though known to exist in nearly all countries, can hardly be said to be common. The writer, in an experience of over thirty years in bee keeping in several States of the Union, as well as in a number of foreign countries, has met the disease but rarely, and has had but one experience with it in his own

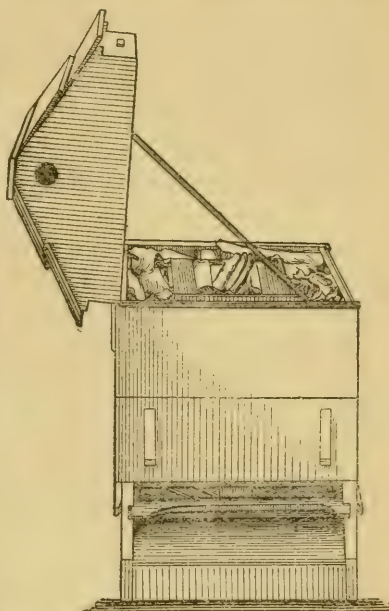


FIG. 19.—Colony of bees with newspapers packed between inner and outer cases and brood frames on end for the winter.

apiary, it having been in this instance brought in by a neighbor who purchased bees at a distance. It was easily cured, without great loss. Thus the beginner's risks of disaster in this direction are, if he be forewarned, comparatively small. He may, furthermore, gain assurance from the fact that, should the disease invade his apiary, prompt and intelligent action will prevent serious loss.

The following is the treatment for a colony which still has sufficient strength of numbers to be worth saving: The bees are to be shaken from their combs just at nightfall into an empty box, which is to be removed at once to a cool, dark place. They are to be confined to the box, but it must be well ventilated through openings covered with wire cloth. During the first forty-eight hours no food should be given to them, and during the second forty-eight hours only a small amount of medicated sirup—a half pint daily for a small colony to a pint for a strong one. This food is prepared by adding one part of pure carbolic acid or phenol to 600 or 700 parts of sugar sirup or honey. At the end of the fourth day the bees are to be shaken into a clean hive supplied with starters of comb foundation. This hive is to be placed outside on a stand some distance from all other colonies, and moderate feeding with medicated sirup or honey should be continued for a few days thereafter.

The combs of diseased colonies which contain brood may be assembled over a single one of these colonies, or, if the amount of brood be too great for one colony to care for, over several such diseased colonies, until the young bees have emerged. All of the honey is then to be extracted. While it is wholesome as food, it should not be offered for sale, lest some of it be used in feeding bees or be inadvertently exposed where foraging bees might find it and carry to their hives the germs of this disease, harmless to other creatures but so fatal to bee life. A good use for this honey is to employ it in making vinegar. One and one-third pounds added to each gallon of rain water or soft spring water and allowed to ferment for three months in a warm place makes a quality of vinegar quite equal to the best cider vinegar. Provision for the free circulation of air through the cask should be made. This is easily secured by placing the cask, not completely filled, on its side and boring an auger hole in each end near the upper side, the holes to be covered with cheese cloth or fine gauze, to keep out insects.

If the honey containing the germs is to be used for feeding bees, it is to be diluted with half its own quantity, by measure, of water and kept at the boiling point for three hours in a water bath—a vessel within another containing water.

The combs from which the honey has been extracted, as well as all of the pieces built by the bees during their four days' confinement, may be melted into wax, by thorough boiling in soft water. This wax should be kept liquid for 48 hours or longer, to allow all impurities to settle. These will include the foul brood spores, which may

then be removed with the impure wax by scraping or cutting away the bottom of the cake. These scrapings should be burned. The same disposition had better be made of the frames from which the combs containing germs were removed.

In all of this work the utmost care should be exercised to avoid the dripping of honey about the apiary or the exposure of implements, receptacles, or combs smeared with or containing honey from the diseased colonies. It may even be better, in order to save time and possible risk, where but few combs and a comparatively small amount of honey are involved, to destroy all of these immediately after their removal from the hive. The old hive and all utensils used about the diseased colony should be disinfected by washing in a solution of corrosive sublimate—one-eighth ounce in one gallon of water—and should afterwards be exposed to the air and sun for some time. If healthy colonies are to be manipulated immediately after handling diseased ones the hands of the operator must also be disinfected by washing in the solution just mentioned.

Those who care to try and save combs and brood should employ the remedial method developed by the late Professor Cheshire. This is explained in full in his work on bee keeping,^a and a brief statement of it may also be found in "The Honey Bee," Bulletin No. 1, new series, of the Bureau of Entomology, United States Department of Agriculture. Notwithstanding these remedies, some will prefer, where healthy colonies of bees can be bought at moderate prices, to burn diseased bees, combs, and frames rather than spend time to effect a cure, and risk, as they fear they may, the further spread of the pest. To kill the bees thus is, however, neither profitable, humane, nor necessary, for if confined as described above and separated at once from the other colonies, this work being done at nightfall, when all of the bees are in their hives, the risk of spreading the disease will not thereby be increased, nor is the labor much greater than that involved in the removal of combs and bees for burning. And if it be found that the diseased colonies are weak in numbers and seem, therefore, individually hardly worth saving, this need not be taken as an excuse for the death sentence, as several colonies may be smoked and shaken together into the same box to make a single strong colony, the best queen of the lot having been selected and caged in the box in such a way that the workers can release her within a few hours by eating through candy.

BEE PARALYSIS.

Among other diseases of a bacterial nature paralysis is most noticeable, although not to be dreaded as foul brood. It affects the adult bees only, producing a paralyzed condition of their members and a

^a "Bees and Bee keeping," by Frank R. Cheshire, F. L. S., F. R. M. S., London, 1888, Vol. II, pages 554-575.

swelling up of their bodies. The diseased bees, often set upon by other workers, lose the hairy covering of their bodies, and, black and shiny in appearance, may often be seen wriggling away from their hives to die. In such cases the working force of the affected colony frequently becomes so greatly reduced as to preclude any return in the form of honey or swarms during the given season. The source from which the bees obtain the original infection is unknown, but, once in the apiary, it is spread mainly by the entrance of affected workers into healthy colonies, and probably also by the visits which bees from healthy colonies make to the diseased ones, the latter often being so weakened in numbers as to be unable to protect their stores from healthy bees out on robbing expeditions.

Ordinary paralysis may generally be cured by strewing powdered sulphur over the combs, bees, and along the top bars of the frames, the precaution first having been taken of removing all unsealed brood. This brood would be killed by the application of sulphur, but as there is no danger whatever of spreading the disease by the transfer of brood or honey from one hive to another, provided absolutely every one of the adult bees has first been shaken or brushed from the combs, the latter may be given to healthy colonies which need strengthening.

Another simple plan for getting rid of the disease and yet utilizing the available strength of the affected colonies is to close their hives at night and move them a mile or more, locating them, if possible, outside of the range of other bees. As the brood in these colonies remains healthy all that is sealed or even well advanced in the larval stage may have the bees shaken from it and be distributed among the remaining colonies of the apiary. The bees of the diseased colonies thus become rapidly reduced in numbers, and several of the colonies themselves may soon be combined, the best queen being selected to continue egg deposition. Eventually the diseased apiary becomes, by the removal of the developing brood and the death of the old bees, reduced to nothing. None of the queens should be saved nor should any of the adult workers be returned to the healthy apiary.

A combination of the sulphur cure with the last plan mentioned—that of getting rid of the disease through the removal of brood combs from affected colonies—is really, all in all, the best procedure. When a fairly strong colony has been made up by shaking the adult bees of two or more together and this removed to an isolated locality, the application of sulphur may be made before any brood has been started. It is well, also, to replace the queen with a vigorous one from stock entirely unrelated to the diseased bees. Should any signs of the disease reappear, constant removal of the brood should be followed, as mentioned in the preceding paragraph.

Other bacterial diseases, though existing, have developed only very locally or have been too limited in the amount of injury inflicted to require special mention here.

INSECT AND OTHER ENEMIES.

The bee or wax moth (*Galleria mellonella* Linn.) is regarded by those unfamiliar with modern methods in bee keeping as a very serious enemy to success in this work. It was frequently such when only the common black bee was kept and the old way of managing, or rather of trusting to luck, was followed. But with the better races now introduced and with improved hives and methods, and especially with the care that is now given to have no colonies queenless long at a time, the wax-moth larvæ are no longer regarded with great concern.

Some species of wasps take a little honey at times—more particularly when hives are opened—and they annoy the bees; others capture and eat workers, as do also the large ant-like “cow-killers” (Mutilidæ), and certain predaceous flies (Asilidæ), true bugs (Phymatidæ), and neuropterous and orthopterous insects (Libellulidæ and Mantidæ). The larvæ of certain beetles (Dermestidæ and Tenebrio) feed upon pollen and the cast-off skins of developing larvæ and pupæ, and certain of the Meloid larvæ attach themselves to the bodies of bees as parasites. Ants (Formicidæ) and cockroaches (Blattidæ), which gather above the quilts and between the quilts and the tops of the frames in order to be benefited by the warmth of the cluster of bees, sometimes help themselves to honey, and their presence annoys the bees more or less. Some of the insects here mentioned are only found locally, the predaceous ones being confined mainly to the South, while it may be said that the general welfare of strong colonies is not often materially affected nor the return noticeably reduced through the attacks of any of them.

Spiders, toads, and lizards destroy, in addition to many injurious insects, also some bees, and should be tolerated in the vegetable garden rather than in the apiary.

Swallows, kingbirds or bee martins, mice, skunks, and bears only occasionally commit depredations in the apiary.

Properly constructed hives enable the bees to limit in a great measure the injury which these various enemies might inflict, and the avoidance of overswarming, with care to insure the constant presence of a prolific queen and a supply of food suited to the needs of the colony at the time, will keep it populous and therefore in shape to repel attacks or to make good most of the unavoidable losses.

ROBBER BEES.

Robbing is sometimes a more serious matter, although it very rarely happens that a little careful attention just at the right time on the part of the bee keeper would not avoid all serious trouble on this score. When bees find nothing to gather during weather when they can still fly out they are easily tempted to appropriate the stores of weaker colonies. Exposure of combs of honey at such times may even occasion a combined attack upon a good colony otherwise quite able to take

care of itself. It is then that the greatest destruction ensues, for such a colony will defend itself vigorously, and a pitched battle, with perhaps fifty or sixty thousand Amazons on either side, leaves the ground literally strewn with dead and dying.

If the invaders conquer, every drop of honey is taken from the few vanquished that are likely to be still alive; and in turn the despoilers invariably fight among themselves as to the possession of the booty. When the robbing takes place during the absence of the owner, the condition of the robbed colony may not attract immediate attention, and during warm weather moth larvæ gain full possession of the combs within a few days. When this condition is observed, the whole damage is very likely to be attributed to the moth larvæ. Colonies that have been left queenless for some time, and those weakened by disease or by overswarming, are especial marks for such attacks. Of course these defects should be remedied whenever observed, but meanwhile, if legitimate field work is likely to be interrupted, every colony should be assisted in protecting itself against assault by having its hive made secure and the entrance such a narrow pass as to enable a few workers to repel attack there.

Should robbers get well started before being observed, the entrance of the hive should be narrowed at once, and wet grass or weeds may be thrown loosely over it, or a pane of glass may be stood against the front of the hive in a slanting manner to confuse the intruders. In extreme cases the attacked colonies may be removed to a cellar for a few days, plenty of ventilation being given during confinement, and a new location, apart from other colonies, selected, on which they are to be placed just at nightfall; or, instead of putting them in the cellar, they may be taken a mile or more away and returned only when the danger has passed. With these precautions, little loss is to be feared on this score.

In general, the intelligent owner who gives careful attention to certain important points in bee management finds that he very rarely has disease to contend with, and that the reduction of profits through the depredations of bee enemies is not, in most parts of the Union, a serious discouragement. Altogether it seems to the writer that the risks in these directions are even less in bee keeping than those usually met in the keeping of other animals, which, like bees, are legitimately made to contribute to the wealth of the individual and of the nation.

LEGISLATION AFFECTING APIARIAN INTERESTS.

Many States have in recent years passed laws having for their purpose the eradication or suppression of contagious diseases among bees. State and county inspectors have been appointed under these laws, whose duty it is to go about and ascertain where diseased colonies of bees are located, and recommend the treatment to be given, or in some cases to carry out this treatment, even to the complete destruction of

colonies or apiaries where the virulence of the attack seems to warrant it. Where these laws have been conscientiously and energetically executed, much has been accomplished toward freeing the apiaries of the given State from disease.

Some States have passed laws making it a misdemeanor to spray fruit trees during the time of blossoming, since thereby bees are poisoned, and besides the injury to the apiarist the pollination of the fruit blossoms is seriously interfered with.

Laws against the sale of adulterated goods as genuine, known commonly as pure-food laws, are in operation in some of the States, and where bee inspectors or bee keepers have taken the pains to have these laws applied to the marketing of honey, a check has been put upon the selling of adulterated honey in the liquid form, which has been practiced to a greater or less extent and still occurs in some of the city markets.

In general, the rights of bee keepers to own and cultivate bees, either within the limits of cities or on farms adjoining those devoted to grazing and general stock raising, are becoming more clearly defined through decisions of supreme and county courts. In this connection the work of the National Bee-Keepers' Association should receive mention.

This organization is in no sense a trades union, but has for its purpose the defense of its members against unjust attacks upon their legal rights, the suppression, in so far as possible, of the sale of adulterated honey, the securing of legislation for the protection of its members and favorable to the general advance of the industry, as well as the dissemination among its members of advanced ideas in bee management and information regarding the marketing of apiarian products. The membership fee of one dollar per annum entitles every honey producer to membership and participation in all of the benefits enumerated, as well as to the published report of the annual convention held by the association. The membership numbers nearly 2,000 at the present time, and the influence of this large body of intelligent beemasters is already being appreciably felt in the general advance of the industry in this country.

JOURNALS TREATING OF APICULTURE.

As a matter of general information, the following list of journals relating to apiculture is given. It comprises all those published in this country at the present time.

- The American Bee Journal, Chicago, Ill.
- Gleanings in Bee Culture, Medina, Ohio.
- The Bee Keepers' Review, Flint, Mich.
- The American Bee Keeper, Falconer, N. Y.
- The Progressive Bee Keeper, Higginsville, Mo.
- Western Bee Journal, Kingsburg, Cal.
- The Rural Bee Keeper, River Falls, Wis.

DIV. INSECTS,

U. S. DEPARTMENT OF AGRICULTURE.

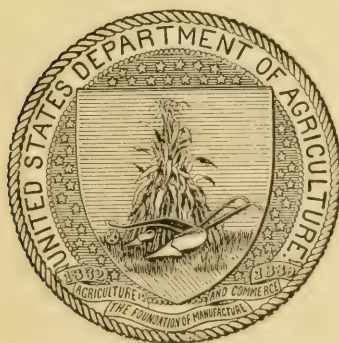
FARMERS' BULLETIN No. 61.

ASPARAGUS CULTURE.

BY

R. B. HANDY,

DIVISION OF PUBLICATIONS.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF PUBLICATIONS,
Washington, D. C., September 30, 1897.

SIR: I have the honor to submit an article on Asparagus Culture, prepared by Mr. R. B. Handy, of this Division. Frequent inquiries for information on this subject led to its preparation. Besides the author's knowledge of the subject, which is considerable, special opportunities have been afforded him for studying the methods of the most experienced and successful growers. The assistance of Mr. L. H. Dewey, of the Division of Botany, was invoked in preparing the matter on the botany of the plant, and that portion of the article relating to fungus diseases has been read and approved by the chief of the Division of Vegetable Physiology and Pathology. The concluding portion relating to insect enemies of the asparagus is the work of Mr. F. H. Chittenden, of the Division of Entomology, who has made a special study of insects injurious to this plant. I have the honor to recommend its publication as No. 61 of the Farmers' Bulletin series.

Respectfully,

GEO. WM. HILL, *Chief.*

Hon. JAMES WILSON,
Secretary.

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ASPARAGUS CULTURE.

INTRODUCTION.

The popularity which asparagus has achieved during recent years is remarkable. Formerly a luxury on the tables of the rich, it is now, during the season, a vegetable seen daily upon the tables of people of moderate or even of small incomes. It is also frequently recommended as an article of diet for the sick and convalescent.

The fact that asparagus appears in the market at a time of the year in which few or no other fresh vegetables are available has had much to do with its increased consumption in our cities. It can also be easily preserved by canning, the product in this form being almost equal to the fresh article, and this has increased its use, being as it were a lengthening of the season. Growth is also easily forced out of its regular season, thus making the vegetable available for use from the beginning of December throughout the entire winter and almost until the regular spring season appears, but this product of the gardener's skill is naturally quite expensive. Field culture, too, is one of the most interesting innovations of the present age, and one which has been attended with the most striking success.

Within the last few years the cultivation of asparagus has been greatly extended, yet the demand is still greater than the supply, an indication that there is still room for an extension of beds by those already in the business and for the establishment of beds by those who have as yet given no attention to this branch of gardening. Every kitchen garden should have its bed, from which the table may be supplied with this most delightful and wholesome vegetable, and it is hardly to be doubted that a diffusion of knowledge concerning the later and improved methods of culture, with their reduced cost and lightened work, would do much to increase the popularity of the vegetable, and bring about its cultivation in gardens where it has never found a place, but where its introduction would add greatly to the present diet of the family.

HISTORY.

The use of asparagus is almost as old as the hills and marshes on which the ancient writers say the two varieties of their day grew. First as a medicinal plant and then as a vegetable it was known to the Romans. Writers of those days praise its virtues with enthusiasm, and the epicure counted it one of the delights of his table. For want

of a better way, the sprouts were preserved by drying, as is done by thrifty farmers' wives to-day to lengthen the natural season. So far had the gardeners of that day progressed in its improvement that Pliny was able to record spears of it weighing three to the pound.

Once made familiar with the use of the native article by the invading Roman soldiery, the Gauls, Germans, and Britons appreciated its value, and it soon became one of their most prized vegetables. Early writers on horticultural subjects leave no room for doubt that as early as the first part of the sixteenth century—four hundred years ago—the use of asparagus was not only general in nearly every part of Europe, but that in some parts its development was such as to put the so-called "colossals" and "mammoths" of the present day upon their mettle, since spears weighing over one-half pound each were not of uncommon occurrence.

In France, Holland, Germany, Hungary, and England asparagus was both gathered by the peasantry in its wild state and carried to the towns for the tables of the prosperous burghers and grown in the landlord's garden for his own table.

The early settlers of America, familiar with its use, brought the seed of the plant with them, and, though not native to this country, it found the climate congenial. John Josselyn, gent., in "New England Varieties," etc., published in London in 1672, says, in a list of "Plants which have sprung up since the settlers planted and fed cattle in these parts," that "asparagus thrives exceedingly."

Although a "cosmopolitan," there are localities where its skillful culture has produced such results, both as to size of spears and average yield, that they are noted the world over as asparagus-growing centers. Many of the States of the eastern coast, from Charleston, S. C., to Boston, Mass., of the Mississippi Valley, and of the Pacific Slope, produce a great amount of asparagus, but it is in Long Island and New Jersey, owing probably to their proximity to the larger seaboard cities, that much attention has been given to its cultivation, and there its culture has reached a high state of development.

BOTANY AND VARIETIES.^a

The genus *Asparagus* belongs to the Lily-of-the-Valley family. It includes about 100 species, all native in the Old World. A few species, including the familiar asparagus vine and the smilax of the florist, are in common cultivation for ornamental purposes, but most of them, having no recognized economic value, are known only to botanists. All of the various forms and varieties of the vegetable, now in common cultivation under the name of asparagus and sold in the markets as "grass," have been derived from one species, *Asparagus officinalis*.

^aThe first paragraph under this heading was prepared by Lyster H. Dewey, an assistant in the Division of Botany, United States Department of Agriculture.

This is a branching, herbaceous plant, growing to a height of 3 to 7 feet from perennial rootstocks. The rootstock or "crown" makes a new growth each year of from 1 to 3 inches, extending horizontally and generally in a nearly straight line. It may propagate from both ends or from only one, but in either case the older part of the rootstock becomes unproductive and finally dies. The upper side of the new portion of the rootstock (fig. 1) is crowned with buds for the production of new shoots, while the older portion bears the scars and dead scales of previous growths. From the sides and lower surface of the rootstock numerous storage roots extend almost horizontally to a distance of 1 to 3 feet. They are light colored and from one-eighth to one-fourth inch in diameter. They often form a complete underground network in old beds, making it impossible to plow or cultivate deeply. These storage roots bear numerous small feeding roots, especially on the newest parts of their growth; hence they fulfill the office of principal roots, but they have in addition the special function of storing nourishment for the growth of the following season.

Although but one species of asparagus is to be found in cultivation there are many so-called varieties. Thus we have Colossal, Barr's Mammoth, Columbian Mammoth White, Donald's Elmira, Palmetto, etc., in our own country, besides the numerous "varieties" cultivated in France, Austria, Germany, England, etc., when in reality there are probably but three or four of them all which deserve to have special names, being nearly all susceptible of classification under the general head of "Giant," or "Mammoth," indicative of the improved size produced by the superior conditions of manuring, soil, climate, and cultivation to which they have been subjected.

Brinckmeier and Göschke speak of four cultural varieties which have such distinct individual characteristics, and whose seed reproduce these in the plant, as to entitle them to special notice: The German Giant—in which the Holland, English, and most of the French and American kinds are embraced—the Early Argenteuil, Conover's Colossal, and the Yellow Burgundy.

Through natural and artificial selection, through use of seed from strong shoots from superior roots, there has been improvement in the size and yield of asparagus; from the peculiar adaptability of soil and climate and the effect of manure and high cultivation there have



FIG. 1.—Asparagus crown, roots, buds, and spear. (Redrawn and reduced; from plate 113 of Thomé's *Flora von Deutschland*.)

appeared certain variations in the product of different beds which have led to the bestowing of a new name; but the effect of this care and these favorable conditions is not sufficiently strong to produce distinct varieties with fixed characteristics. Generally these "varieties" differ only in a single characteristic, and these differences, for the most part, are so little constant that they are lost when grown under different climatic and soil conditions. Therefore, with correct and rational treatment of the plant from time of seeding through all the stages of culture, satisfactory results may be reached with almost any of the varieties on the market.

PRODUCTION OF PLANTS FROM SEED.

To the asparagus grower there are two methods by which plants can be secured, (1) by purchasing or saving the seed from which to raise them, and (2) by purchasing the plants from either a seedsman or some grower. Taking the second method, as being the quickest way to start a bed as well as the most easily disposed of, it is suggested that roots over 2 years old be rejected, and only 1-year old roots selected if a sufficient number can be secured, as the latter are much better and will in the course of a few years produce more and larger spears to the plant and yield profitable crops for a longer period. It is best to deal with reliable firms; they will be more likely to supply plants of both the kind and age desired. It is extremely difficult for anyone not an expert to distinguish the difference between the various sorts, and doubtless many "varieties" are often supplied from the same lot of roots; nor is it easy to tell the difference between a strong, well-grown 1-year plant and a small and stunted 2-year old (the left over of last year's supply) left unmanured, uncultivated the second season, that the development might be retarded.

SAVING THE SEED.

For the above reasons only reliable seedsmen should be trusted, or the seed should be procured from some neighbor who has the desired variety and has taken proper care in producing and saving the seed, if the first plan is to be followed. If one already has an asparagus bed of the desired sort, producing fine spears, and of the proper age (8 to 12 years old) for seed production, it is always best to save seed from it for new plantings.

The growing of one's own plants is preferable, both because of the extra year intervening between the determination to plant and the actual setting out of the bed, thereby permitting the soil of the proposed bed to be put in a better and more friable condition, and because, good seed having been secured and proper care given to the young plants, a more satisfactory supply of the young roots is obtained.

That there are objections to growing one's own seed is undoubtedly true, but there are also compensating advantages, and if proper care is exercised it will pay the grower to raise his own seed (from beds

which are satisfactory) even if seed can be bought in the open market for much less than the trouble of attending to the home grown may cost. If, however, a grower is unwilling or unable to exercise the necessary care in the production of seed, he would do much better not to attempt it, but depend upon some reliable dealer, studiously avoiding those whose claims to patronage are based upon cheapness of stock. Good seed are worth good money; poor seed should not be accepted under any conditions.

Since asparagus is propagated only from seed, the natural tendency to atavism and resistance to constancy and reproduction in form makes difficult the maintenance of a certain combination of desirable qualities in any variety. Therefore, even if the seed are secured from a bed which has distinguished itself for a large yield of fine spears, a new bed with like qualities is by no means insured. A careful selection should be made of seed-bearing shoots (fig. 2) possessing the desired characteristics, the seed should be fully developed before they are gathered, the young plants should receive the best attention, and both in planting and future attention the bed should receive thorough and rational treatment. If these are neglected it is not to be expected that the bed will be a success.

Any observant grower will become aware of two facts connected with his bed, (1) some clumps each year produce larger, earlier, and finer spears than others, and (2) some stalks bear seed while others do not. In connection with these it is ordinarily found to be true that the clumps producing nonseed-bearing stalks bear the largest spears.

During the spring cutting of the year preceding that in which the seed are to be saved, the clumps producing the largest, finest, and earliest spears should be marked, selecting four or five seed-bearing to one producing nonseed-bearing stalks; these should be as close together as possible, or in bunches, that the pollen may not fail to be effective. When spring comes, one or two of the largest and earliest stalks of each of the hills should be permitted to grow, cutting the later-appearing spears just as is done with the other spears for market. Thus these early stalks of both male and female plants will bloom together before



FIG. 2.—Asparagus stem, leaves, flowers, and berries. (Redrawn and reduced; from plate 113 of Thomé's Flora von Deutschland.)

any other stalks, and the blooms on the female plants will be fertilized with the pollen of the selected male plants. This is of importance, for on proper fertilization depends the purity of the seed as well as the vigor of the resultant plants.

Not all seed of even a good plant properly fertilized should be used for reproduction, as of the seed gathered from any plant some will be better than others. Only the largest, plumpest, best-matured seed should be used, for by saving these the most nearly typical plants of the sort will be more certainly produced. The selection of the best seed from typical plants is as essential to success as are good soil, thorough cultivation, and heavy manuring.

The best seed are produced from the lower part of the stalk, hence it is well to top the plant after the seed are well set, taking off about 10 inches, and to remove the berries from the upper branches, that all the strength may go to the full development of the more desirable berries. If, after this has been done, there is more than sufficient seed for the purpose desired, a second discrimination can be made between the seed of plants which produce numerous berries and those which are shy bearers, the latter being desirable, as this indicates a tendency in the plant to produce stalk rather than fruit, and it is as a stalk producer that asparagus is valuable.

Harvesting, cleaning, and preserving the seed is, of course, to be done carefully; the separation of the heavy and light seed can be accomplished by means of water, while the larger can be selected from the resultant mass by the use of a properly meshed sieve.

When the berries are scarlet red and fully ripe, the entire plant is cut near the ground and put away where it is free from rain or dampness, and safe from the attack of birds or from other damage.

When there is somewhat more leisure, the berries are stripped off, soaked in water for thirty-six or forty-eight hours to soften the skin and pulp of the berry, and then rubbed between the hands until the black seed are freed entirely from the pulp. Spread and dry and put away in a paper or linen bag until needed. It is not wise to use seed over 2 years old, although they will retain some vitality for several years.

Fresh seed may be distinguished by the uniform smooth surface and the brilliantly black scale; the old seed have a smutty, gray color, and the surface is much roughened and wrinkled. One pound of seed will produce about 3,000 sprouts, and should be sown in a light, rich, sandy soil in rows about 15 inches apart and $1\frac{1}{2}$ inches deep; so thinly should the seed be sown that the plants will not stand closer than $1\frac{1}{2}$ or 2 inches, and these should afterwards be thinned by hand to about 3 inches apart, care being taken to leave the strongest and most thrifty shoots.

Careful weeding and hoeing are needed throughout the growing season, and in dry weather irrigation will greatly increase their growth.

Watering between the rows with liquid manure is of great assistance to the young plants, which with the care indicated above should bring large thrifty plants ready for setting out in the beds early the next spring.

SELECTION OF PLANTS.

Much depends upon the selection of plants. A good strong "crown" with few but well-developed buds and plenty of roots is essential to the production of large and thrifty spears. A "crown" with numerous buds, or eyes, will be more than likely to produce numerous but small spears, and afford a total yield much less than the other kind.

As has been previously stated, 1-year-old crowns are to be preferred, as it has been proved that in the course of years the 1-year-old will produce larger and more valuable crops than either 2 or 3 year olds, although this was not formerly the opinion of growers. Small 1-year crowns, while not as desirable as large ones of the same age, are preferable to larger crowns 2 years old, and at the end of a year or two will be as large, more vigorous, and more productive. For instance, Lebœuf, who planted twelve crowns each of 1, 2, and 3 years of age, found at the end of the third year of identical treatment, in the same soil, the yield was as follows:

	Pounds.
One year old.....	7
Two years old.....	33 $\frac{1}{2}$
Three years old.....	24 $\frac{1}{2}$

The 1-year-old plants at the end of three years yielded almost twice as much as the 2-year-old and nearly three times as much as the 3-year-old crowns.

There is something also to be said in favor of selecting plants which bear only staminate flowers, for, as these do not produce seed, the strength which would be taken to mature the seed goes to the storage of nourishment in the roots, thus enabling them to produce larger, earlier, and better spears for the next spring's cutting.

Prof. W. J. Green, in a Bulletin of the Ohio Agricultural Experiment Station (Vol. III, No. 9, second series, 1890), reports observations on this point. In order to determine the difference in vigor between the seed-bearing and nonseed-bearing plants, fifty of each were staked off, and when cutting commenced the spears taken from each kind were kept separate and the weight of each recorded, with the following result:

Period of growth.	Product from fifty male plants.	Product from fifty female plants.
	Ounces.	Ounces.
First period of ten days.....	37	21
Second period of ten days.....	104	68
Third period of ten days.....	266	164
Fourth period of ten days.....	203	154
Total for season.....	610	407

This shows a gain of male over female plants of 76 per cent for the first period and a fraction less than 50 per cent for the whole season. There was a still further difference in regard to quality; the spears of the male roots, being earlier, larger, and finer, had also a higher market value. It is not safe to draw definite conclusions from this one experiment, but the experience of many growers corroborates these results. Male plants can be secured by selecting roots whose stalks have borne no seed. This can often be decided with large well-grown yearling plants, and when two years old, the presence or absence of seed will be an indication of the sex of the plant, and it might be profitable to use 2-year-old plants, if only male plants are selected, because of the probable increased yield of large early spears.

SELECTION AND PREPARATION OF SOILS.

Selection comes before preparation and is equally important. Although a bad selection may be counteracted by methods of preparation, just as improper preparation may be corrected by means of cultivation, both efforts at amelioration are extremely costly.

Asparagus will grow on most soils, and will yield large crops upon stiff soils; but for the purpose of the grower for market, a light sandy soil of fair fertility is much to be preferred, both because of the earliness with which it produces marketable spears and the ease with which it is cultivated.

A soil on which water stands after rain, or under which the standing subsurface water is near the surface, into which the roots are liable to penetrate, is to be avoided. Of course, such a soil, if otherwise suitable, can be made fit by a thorough system of underdrainage, since an occasional overflow, or even a submergence of the beds for several days, is not necessarily injurious if the drainage, either natural or artificial, is good. There are instances where established beds have been under water for a lengthy period during heavy spring rains or very high water and were not injured. Göschke, in his book on *Asparagus Culture*, relates two instances, one in Germany at Merseburg on the banks of the Saale, where for six weeks in early spring the water covered the beds; and the other at Everly, some 75 miles east of Paris, where water stood many weeks during the winter upon large stretches of asparagus land, yet in both instances the succeeding crops were both early and large—better, in fact, than on land which had not been overflowed. Of course, the soil was light and porous, never becoming baked, and the natural drainage was good.

The soil should be free of roots, stones, or any trash that will not readily disintegrate or that will interfere with the growth of the spears. Yet the writer knows a rather stiff but naturally well-drained soil which produces early and fine asparagus, notwithstanding the fact that it is full of large gravel, some of the stones being twice the size of a man's fist.

Fruit or other trees or high shrubs must not be allowed in the asparagus bed, because of the shade they throw over the beds and because their roots make heavy drafts upon the soil. Nor should high trees, hedges, hills, or buildings be so near as to throw a shadow upon the beds, because all the sunshine obtainable is needed to bring the spears quickly to the surface.

The land should be protected from the north or east (or from the direction of the prevalent winds) and so slope that the full benefit of the sunshine will be obtained during the whole day. Brinckmeier, in his "*Braunschweiger Spargelbuch*," gives the following three rules for guidance in selecting a location for asparagus beds:

(1) One should choose, in reference to ground characteristics, open, free-lying land, protected to the north and east, of gradual slope, free from trees or shrubbery.

(2) The field should be exposed to the rays of the sun all day long; therefore a southern exposure is desirable, or, if that is not obtainable, a southwesterly or southeasterly slope, because either east, west, or north exposure will cause shadows during a greater or less portion of the day.

(3) Standing, stagnant groundwater, which can not be drawn off by drainage, is to be avoided, the requirements of the plants indicating a somewhat damp subsoil, but not too high groundwater.

From the above it is deduced, and experience corroborates the theory, that a not too porous, but a well-drained, light, deep, sandy loam, with a clay subsoil, is to be preferred to all others.

Freedom from weeds is very desirable, even more so than great fertility, for the latter can be produced by the heavy manuring which the future cultivation will require; and to the end that weeds may be few, it is well that for a year or two previous to planting the land should have been occupied by some hoed crop, such as potatoes, beets, cabbages, etc.

In the late fall or early winter the selected area, should it be a light sandy loam as described above, needs to be deeply plowed, and if the subsoil is not already of an open and porous nature, through which surface water will readily drain and the roots easily penetrate, a subsoil plow should follow, breaking the soil to the depth of at least 15 inches. After harrowing the field, a good compost of well-rotted horse, cow, sheep, or other manure should be spread broadcast and left to the action of the weather until as early in the spring as the ground is in condition to be worked, when the manure should be plowed in, the surface carefully harrowed, and the soil put in a light and friable condition.

Formerly it was customary to trench the whole field, and in case the soil was too binding and stiff, to mix in sand, etc., in order to ameliorate its condition. In fact such practice is still commonly followed among the intensive growers in the thickly populated countries of Europe. But trenching is very expensive, and it has been proved to be unnecessary, and in some soils, where, for instance, the soil was sand with but little humus, the placing of the better soil below, with the unfertile sand above, is a positive detriment.

PLANTING AND CULTIVATION.

Spring is the best time to plant, but planting is often extended or delayed until the last of June, and in some more southern sections it is done in the autumn. In this bulletin the subject is treated from the standpoint of spring planting. It is perhaps because of the fact that most of the work of preparation can be done in the pleasant fall weather, and because of the beneficial effect of the frost, snow, and winter rains upon the freshly plowed land, that spring planting is preferred; but there are also some advantages which attend the planting itself that are of importance. In the spring the roots bear transplanting with less injury than later in the year, and the early spring rains insure against the necessity of watering the plants, which would have to be done at the midsummer season. In the fall planting, it depends too much upon the following winter whether the roots would not be winterkilled.

As early in the spring as the condition of the ground will permit work to be done—when it is dry enough to bear plowing and the soil will break up fine—rows should be marked off 4 to 6 feet apart and opened up with a large plow, going a sufficient number of times to make a furrow from 8 to 12 inches deep. Loose soil that the plow does not throw up should be taken up with a shovel or wide-bladed hoe. It is in these furrows that the crowns are to be set, the distance to be left between plants varying, according to the opinion of the grower, from 18 inches to 5 feet.

The question of distance between rows, and between plants in the row, is one about which there are many diverse opinions, each grower defending his adopted space, either upon his idea of the needs of the plant or the purpose he has in view. For example, three men from different sections, each of whom is a successful and intelligent grower, writing to the author on this subject, differ widely on this point. The first has a sandy loam, naturally well drained; he says, "rows should be 6 feet apart, plants 4 feet distant down the row and 12 inches deep." The second, with a loamy clay soil, suggests as the best arrangement "4 feet between the rows, 18 inches in the row between plants, and from 4 to 6 inches deep." The third, with a light sandy soil, "prefers rows 5 feet apart, plants $2\frac{3}{4}$ feet from each other in the row, and crowns 6 inches below the level of the soil." Of three German authorities, Göschke recommends 52 inches between rows and 40 inches between the plants in the row, and a few inches deep; Binz describes the proper distance to be 47 inches by 39 inches and the rows 8 inches deep; Brinckmeier will not agree at all to the advantage of the single-row bed, maintaining that the double-row bed is equally advantageous for the growth of the plants, and much better for the grower, as the yield is larger.

Lebœuf, a French authority, says:

When planted in an open plat, the shoots should be $3\frac{1}{4}$ feet from each other, but if two are grown side by side (double rows) they should be $2\frac{3}{4}$ feet apart. For our own beds we have adopted a uniform distance of 4 feet between the lines, the plants

being $3\frac{1}{2}$ feet apart. Whatever may be the distance, the weight of the crop is about the same if the crops be kept properly apart, but crowded asparagus beds produce late and smaller crops of very inferior appearance and quality.

Of course inferiority means a low price per bunch. Besides, the beds will not continue profitable so long if too closely planted. They are more liable to attacks from insects and disease, require more manure, and are more difficult to cultivate. It would seem that the advantages resulting from plenty of room are a full compensation for the extra ground occupied.

The depth to which roots should be planted is somewhat dependent upon the soil and somewhat upon the method of cultivation and the kind of produce desired.

It is reasoned by those in favor of deep planting that as the crown is built anew every season a fraction of an inch above the old one, and a bed is expected to live and produce profitably for from twelve to twenty years, room should be allowed for the new growths before the new crown will reach the surface of the soil; otherwise it will be necessary to raise the entire surface by addition of soil. Elevating the surface is expensive, but the crowns will be injured by cultivation if they are allowed to come too close to the surface, and so, unless planted deep originally, will require to be covered by raising the surface of the soil.

It is admitted that deep planting makes late sprouting during the first few years, yet that is of small matter until the crowns are old enough to bear having the shoots cut; and besides, by "opening up the rows," i. e., throwing up ridges between the rows each spring, the roots will get the heat from the sun, and the soil can be gradually worked back upon the rows after the action of the sun's rays has started the young growth and before the shoots reach the top. The whole surface can be left level, if green asparagus is to be cut, or be ridged, if white asparagus is desired.

On the other hand, equally strong arguments and equally good results are presented by the advocates of shallow planting.

Rows should be run north and south, so that the full benefit of the sunshine will be secured. If the rows run east and west, they will be shaded by the ridges in early spring, when the sun is low in the south, and later in the season they will be completely shaded on one side by the tall foliage. This delays sprouting in the spring, and prevents the best development of the plants at all times. Of course, any conditions, such as the slope of the land, etc., which make it inadvisable to run the rows north and south must be considered, but southeast to northwest or northeast to southwest is better than due east or west, or, in short, the natural conditions permitting, the course should be as far from east and west as possible. This is especially important to those who ridge the rows to produce white asparagus.

When one recalls the care and exactness with which asparagus roots

were set out a few decades ago, or reads the explicit directions given by all European writers, the methods used by many of even our best market gardeners of to-day do not appear to come up to the correct standard of culture. Inquiries among asparagus growers go to show that beyond seeing that the crowns are right side up and the distances approximately maintained, but little attention is paid to placing them. Yet considering the advantages which accrue from a good stand, i. e., having all of the same age, thus preventing the different treatment which clumps of varying ages will for the first few years require, as well as the trouble of replanting and the loss of a year's cutting, almost any pains taken to plant correctly would be time, trouble, and money saved. It is in fact very little trouble to spread the roots evenly in the bottom of the furrow; or even to form a small hill in the bottom, over which to place the roots with the crown resting on the top, does not require any great amount of time over and above that required to place the roots haphazard in the row.

The former plan of putting manure in the bottom of the row before planting, as well as that of loosening the soil at the bottom so that the roots will find an open soil, have been abandoned, the former because top dressing and mulching has proved superior, and the other because it has been found that asparagus roots are mostly lateral, some even growing upward from deeply planted crowns, and that those which grow downward thrive best in a more compact stratum. The crowns should be promptly covered with about 3 inches of friable soil, and this is readily done by a 1-horse plow (the moldboard having been removed) being passed down the side of the rows. This leaves the plant in a depression, the soil thrown out in opening the rows forming a ridge on each side. This depression will gradually become filled during the process of cultivation during the succeeding summer.

Careful weeding and loosening of the soil at frequent intervals during the growing season is necessary to keep down the weeds and grass, and to preserve a mulch of loose soil to retain the moisture and avoid having to water the young plants.

It is the practice of some growers to stake each plant with a stout stick or stave, to which the stalks are tied as soon as they are 18 inches high, in order that the winds may not disturb the roots and thus injure the vitality of the plants; for, as they grow to the height of 30 to 60 inches, presenting a leafy top to the winds, they are easily shaken backward and forward to the detriment of their roots. In large beds this is not done because of the cost, and an effort is made to support the stalks by throwing a furrow to each side.

In the fall when the tops are mature, they should be cut, hauled off, and burned; and part of the soil over the crowns should be removed, so that not over two or three inches remain, that the frost may penetrate and loosen the soil and the rains improve it. This is the reverse of the former practice, when the rows were covered with manure for fear

the action of the frosts should kill the plants. This fear has been allayed. Asparagus roots will never be hurt by frost as long as the crown is covered with a layer of soil 2 inches deep. (Lebœuf.)

Early in the spring of each year, after the plants are old enough to cut, there must be a ridge made over the rows to blanch the shoots, if white asparagus is to be cut; and once ridging is not sufficient, but after the spears begin to appear the ridges will need renewing every week or ten days during the cutting season, as the rains beat them down and the sun bakes a crust upon the top.

With a 1-horse cultivator go between the rows, and then with a 2-horse disk wheel cultivator with two disks on each side go astride each row, throwing up fresh soil upon the ridge. A 12-inch disk on the inside next the ridge, with a 20-inch one on the outside, makes a very effective implement, especially for rather stiff land; but a homemade ridger, formed of two heavy oak boards shod with tire iron, sloping upward and backward, attached to a pair of cultivator wheels, works very successfully in the light sandy soil of eastern Long Island. Some growers leave these ridges undisturbed until late fall and even early spring, but it is better practice to plow them down and run a harrow in both directions crosswise over the field immediately after ceasing to cut and before the tops are allowed to develop. At this time an application of well-rotted stable manure, bone and potash, or liquid manure is in order.

The grower of green asparagus has about the same work, less the ridging and plowing down. As it is necessary to keep down all weeds, some hoeing may be necessary as supplementary to a free use of the 1-horse cultivator. After the cutting season, a cut-away harrow run twice diagonally across the rows loosens up the soil and destroys a vast number of weeds without injury to the crowns, although some spears may be broken off.

Soon after the tops are allowed to develop they become bushy enough to shade the ground and prevent the growth of weeds; so little work will be required, if the weeds have been pretty well killed by the harrowing suggested above, until the end of the growing season.

The bushes should be cut as soon as the berries are fully colored, as the growth will be sufficiently matured so that no injury will be done the roots by removing the tops, thus avoiding a further drain upon the roots to mature the seed, and preventing the dropping of seed, followed by the springing up of innumerable young asparagus plants.

All brush should be promptly collected and burned, that there may be no lodging places for insects and diseases. In case the fields were not leveled, harrowed, and manured at the close of the cutting season, now is a convenient time to perform this work, although if the soil is rather too moist it is well to leave the surface firm, that the winter rains may run off rather than penetrate to the already too damp subsoil around the roots.

MANURING BEDS.

In nothing relating to asparagus has there been a greater change than in the practice of manuring. Formerly it was thought necessary to place large quantities of manure in the bottom of the deep trenches in which the young plants were set out "in order that sufficient fertility might be present for several years for the roots, as after the plants were once planted there would be no further opportunity to apply the manure in such an advantageous place;" it was also considered necessary to use much manure every autumn to bank the beds in order that the crowns should not be injured by the winter's frost. These applications, especially that given prior to planting the young crowns, made the outlay so great, and that for so many years before any return would be received from the bed, that only small plantings were possible to those who were without considerable capital.

Although asparagus is still heavily manured, the amount now used is much less than was formerly supposed to be necessary, only about double the quantity ordinarily used upon root crops, such as potatoes, beets, etc.

It is not a good practice to put manure in the bottom of the trenches or furrows when setting out the crowns, because it is demonstrated to be rather a waste of manure than otherwise, and besides the roots of asparagus thrive better when resting upon a more compact soil; nor is it necessary that the soil should contain great amounts of humus or be in an extremely fertile condition when the plants are first put out, since by the present system of top dressing a moderately fertile soil soon becomes exceedingly rich and equal to the demands which the plants make upon it.

Considerable improvement is produced in the mechanical condition of the soil by the use of stable manure upon beds. By the addition of humus, porous sandy soil is made somewhat more binding and its ability to take up and retain moisture thereby increased; while, on the other hand, cold, heavy soils are made warmer and more porous. Lierke, in his work on Orchard and Garden Culture, says: "On 'raw' ground it is necessary during the first years to give heavy applications of stable manure, but later, when there is an amelioration in the condition, this may be omitted." In another place he remarks: "If one has but a limited amount of manure, it is best to properly manure only a portion of the field each year, and arrange so that each portion may be so treated every two or three years."

All organic manures are suitable for use on the beds: but care must be exercised in the use of any of these lest they be too hot and injure the plants, especially if applied directly to the roots and immediately over the crowns. Where the young shoots come up through it, fresh, hot manure is likely to produce rust or to render the shoots unsightly and thus injure their sale. Especially is this true in light, sandy soils.

The practice of adding to such manurial materials of the farm as stable manure, vegetable compost, etc., single commercial manurial substances that will enrich them in the direction desirable for the particular crop to be raised does not yet receive that degree of general attention which it deserves. In the case of asparagus, an addition of potash in the form of muriate or sulphate of potash, or of phosphoric acid in the form of fine ground South Carolina or Florida soft phosphate, etc., will in many instances not only improve their general fitness as complete manure, but quite frequently permit a material reduction in the amount of barnyard manure ordinarily considered sufficient to secure satisfactory results.

An average of several analyses of barnyard manure.

Constituents.	Per cent.	Pounds per ton.
Moisture	67.00	1,340.0
Nitrogen	.52	10.4
Potassium oxide	.56	11.2
Phosphoric acid	.39	7.8

The average barnyard manure contains a larger percentage of nitrogen; as compared with its potash and phosphoric acid, than is generally considered economical. An addition of from 30 to 40 pounds of muriate of potash and of 100 pounds of fine ground natural phosphates (soft Florida or South Carolina floats) per ton of barnyard manure would greatly increase its value as an efficient and economical fertilizer.

Judging by the amount used and by the expressed preference of growers, stable manure free from straw or other long bedding is the most desirable for use upon beds. Besides stable manure, farmyard, sheep, hogpen, and henhouse manure, and night soil are also available when used in compost; and if the compost has been lying long enough to have caused the materials to be reduced to a uniform, well-mixed mass there is nothing better for use at the time of transplanting to cover the young plants.

In addition to these farm manures, chemical or commercial fertilizers are also available and are used alone, in connection with stable manure, and in alternation with the same. Of late years these are being more and more used by growers who are without a large number of farm animals and so far removed from large cities that they find stable manure too expensive, especially as the only advantage of stable manure over these is the humus it adds to the soil and its beneficial effect upon the mechanical condition of the soil, as already explained.

The New Jersey Agricultural Experiment Stations, in planting a trial bed of asparagus, used, "April 11, 400 pounds per acre of a mixture containing 150 pounds nitrate of soda, 400 pounds ground bone, 250 pounds bone black, and 200 pounds of potash, and on May 8 another application of 600 pounds per acre of the same mixture, thus supplying in all 41 pounds nitrogen, 100 pounds potash, and 120 pounds phos-

phoric acid per acre. The following year the same amounts were repeated. The bed was on a sandy loam of good, natural drainage and well adapted to the growth of asparagus."

At the same place experiments were started in 1896 on four plats. Plat 1 received 18 tons per acre of stable manure; plat 2 received 650 pounds per acre of general fertilizer at planting; plat 3 received 650 pounds per acre of general fertilizer at planting and 150 pounds ground bone and 150 pounds muriate of potash November 2; plat 4 received 650 pounds general fertilizer at planting, 200 pounds nitrate of soda July 22, and 150 pounds ground bone and 150 pounds muriate of potash November 2. Of course these are trial amounts, but they ought to suggest the manuring needed, and will, when the experiment is concluded, add to the present knowledge on the subject.

An experienced and well-known New Jersey grower of asparagus, whose farm has a light sandy soil, writes of manuring as follows:

At planting use a good fertilizer in the row. Early in the spring of the second year make a furrow with a 1-horse plow down the row on top of the asparagus and give a good dressing of composted stable manure. Plow on a furrow from each side, making a ridge, which is left until nearly time for asparagus to appear, when it is leveled off with a 2-horse harrow, or, perhaps better, put 3 by 4 inch scantling under the harrow, and level off, making a flat bed. This is repeated each year until the asparagus crowns get too near the surface, and then a furrow is run down each side of the row, and filled with manure, the ridge left between the two furrows being cut down by a cultivator.

Another grower of green asparagus in the same general section, whose beds are great producers, and whose "grass" commands a top price in the markets of Boston and New York, has never used a pound of manure on his asparagus, depending entirely upon chemical or commercial fertilizers.

A Virginia grower, whose farm is a sandy loam, and whose asparagus (green) sold at top prices for "Southern grass" during the season of 1897, writes on the subject of manuring as follows:

The soil should be rich to start with, and kept so. The first spring, at time of planting, I sow in row, after having covered roots about 2 inches deep, 500 pounds raw bone and cover same with about 1 inch of soil. The next spring I sow 500 pounds raw bone broadcast per acre and harrow in, but 1,000 pounds would be better. Every third year a heavy dressing (25 tons) of fine well-rotted manure should be broadcasted and well worked in with cutaway harrow in addition to the 500 pounds of raw bone, and every third year 500 pounds of kainit should be broadcasted per acre.

Nitrate of soda and sulphate of potash mixed with wood ashes applied in two doses (March and May) keep the asparagus beds going and produce a large yield of fine spears.

Sulphate of ammonia (one part) and muriate of potash (two parts) applied in three doses (March, May, and after the cutting season is over) has been found to be a mixture which proved a very profitable fertilizer for asparagus.

The use of a light dressing of fish manure several times during the season is recommended, as this fertilizer is excellent and cheap.

The application of liquid manure during the early growing season is of undoubted benefit, and the addition of potash and phosphoric acid to the stable manure will make the latter much more valuable and bring its proportions nearer to those of a complete fertilizer.

When potash salts (kainit or muriate) are used, the application of salt will be superfluous, even if it is ever necessary. On clayey soils salt is always dangerous, causing the soils to run badly and become pasty, while its benefits, except as a weed destroyer, are of a doubtful character.

The time of applying manure on beds, and the position where it should be placed, are of some importance. In the use of stable manure, both writers upon the subject and growers actually engaged in producing asparagus for the market almost unanimously state that "in the autumn, after the stalks have matured and have been cut, manure should be applied on top of the rows." Some give the caution not to put it just over the crowns, lest the shoots next spring be injured by contact with it.

This plan of top dressing beds during the autumn or early winter is gradually giving way to the more rational mode of top dressing in the spring and summer. It was believed that autumn dressing strengthened the roots and enabled them to throw up stronger shoots during the following spring. This is a mistake.

It is during the growth of the stalks after the cutting season is over that the crowns form the buds from which the spears of next season spring, and it is probable that it is principally during this period that the roots assimilate and store up the material which produce these spears. This being true, the plant food added to the soil and becoming available after the cessation of vegetation in the autumn can have little, if any, effect upon the spears which are cut for market the following spring; it first becomes of use to the plant after the crop has been cut and the stalks are allowed to grow. Thus the manuring of the autumn of 1897 will not benefit the grower until the spring of 1899. In the use of hot, or fresh, manure it may be that the winter season is none too long to permit the fertilizing elements to become available and well distributed throughout the soil, but if well-rotted manure is used there is danger of the fertility being leached out of the soils by the rains and melted snows of winter.

The writer suggests feeding when the roots can absorb the manure instead of placing a large quantity of it over them after the growing season, when the plant is at rest. Those growers who apply a liberal dressing of stable manure or fertilizer immediately after the cutting season supply the required nourishment to the plants at the time they most need it and can most profitably utilize it in the production of spears. Manure thus applied will also act as a mulch, preventing the

growth of weeds, keeping the soil light and cool, and preserving the moisture intact. It should not be made on top of the row. This suggestion the writer wishes to emphasize.

Manuring in November in many cases does more harm than good, as the mass of manure causes many roots to decay, and those which do survive are weak and only produce small spears. It would be much better to rely upon liberal supplies of food through the growing season than to give manure when the bushes are cut, as at the former period the roots can more readily absorb the food given. By feeding in spring and summer the crowns are built up for the next season's supply of grass. The roots of the asparagus are perhaps always active, but much less so in winter than at any other season, and they will obtain as much nutriment from the soil as they can then use. If heavily covered with manure sunshine is excluded, growth is checked, and the roots have to fight hard for existence at a time when they are none too strong.

In the culture of green spears the manure is best utilized by broadcasting, this application to be followed by a thorough harrowing of the field. When white asparagus has been cut, either manuring in the trench between the ridges before disturbing them or harrowing down the ridges and then manuring broadcast is perhaps the most rational way.

As between manuring in the row and between the rows, the latter should be selected as the evidently advisable one by which the feeding roots of the plants are most easily reached. Placing the manure in the row only reaches those feeding roots which are to be found about midway between the crowns, as just around the crowns are nothing but storage roots, besides it is not desirable to place manure too close to the crowns; but manuring between the rows puts the manure right where the summer rains can carry the fertility directly down into the (as it were) open mouths of the feeding roots.

COST OF AN ASPARAGUS BED.

The cost of establishing and maintaining an asparagus bed is so dependent upon the value of land, the cost of labor, the kind and amount of manure used, and the method of securing plants, etc., that no definite figures can be given, but can be best estimated by the farmer himself, remembering that it is only once in fifteen or twenty years that this has to be met.

A prominent and successful New Jersey grower says:

I can not give the cost in detail of establishing asparagus beds, as so much would depend upon whether one had roots to buy, and upon other matters. Where growers usually grow roots for their own planting the cost is principally the labor, manure, and loss of use of land for two years, upon which, however, a half crop can be had.

The cost of maintaining a bed I can only estimate, as at times all the men on the farm may be at work at the asparagus, and at other times none at all, and I do not

keep an account of the time put in at the asparagus. I should estimate the cost per acre as follows:

Manure (applied in the spring)	\$25.00
Fertilizer (applied after cutting)	15.00
Labor, plowing, cultivating, hoeing, etc.....	20.00
Cutting and bunching	40.00
Total	100.00

A bed well established, say five years after planting, when well cared for should for the next ten or fifteen years yield from 1,800 to 2,000 bunches per annum, or at 10 cents per bunch (factory price), \$180 or \$200.

This agrees very closely with the actual figures of the yield and receipts of another New Jersey grower who in 1896 cut 22,584 bunches from 12 acres, all of which were not in full bearing, or 1,882 bunches per acre, and received \$2,611 net returns from commission houses, or a fraction over 11 cents per bunch. Of course those getting higher prices or larger yields will exceed this, but it is a fair average for those who sell on commission or to canneries.

The cost of good 1-year-old plants ought not to be over \$4 per thousand, and it requires from 1,800 to 3,600 to fill an acre, depending upon the distance between plants; perhaps 2,500 would be a fair number, allowing surplus plants to fill missing hills, or \$10 per acre. The plants can be grown from the seed for half that sum, if that plan be preferred.

The cost of establishing a bed can be somewhat reduced by planting for the first two or three years some early garden crop between the rows, such as potatoes, peas, beets, onions, strawberries, etc., for as the roots are as yet not occupying all the ground there will be no injury to the plants, and the manure and cultivation necessary for the young asparagus will be sufficient for the other crop, hence the receipts for it will be almost entirely net, and yield at least the returns of "a half crop."

The estimate above calls for an annual expenditure of \$40 per acre for fertilizer and manure, which is a liberal allowance; another estimate requires 2,000 pounds per acre of a mixture containing 400 pounds of muriate of potash, 1,100 pounds acid phosphate, and 500 pounds of nitrate of soda, which at market prices can be secured for less than the above sum.

HARVESTING AND MARKETING.

Asparagus is one of the earliest vegetables, especially if the roots are near to the surface or the soil above them has been temporarily removed so that the rays of the sun can easily penetrate to them. Some varieties are earlier than others, and this difference in time of appearance varies from a day or two to several weeks. For instance, the Early Argenteuil is about ten days earlier than the ordinary asparagus grown in the same locality, and the Late Argenteuil at least ten days later; so that there would be nearly three weeks between the

Early and Late Argenteuil. Among the ordinary varieties, however, there is only a short period between the earliest and the latest.

In the present condition of market gardening, and because of the means of transportation now at the command of most growers, earliness is not so important a feature as it would be were all cities and towns supplied by their own immediate suburbs. It may, however, be of some advantage to the grower in the far South to have an extra early variety, as these growers are the first in the market, or it might pay a "local" grower to have both early and late, in order to have a long cutting season as well as to get early prices, if his market depends entirely on local supplies; but as the season for asparagus in more northern localities approaches there is no peculiar advantage to be gained from an early variety, as the "edge is already off the market," and the very early asparagus not only runs the risk of a belated frost, but may strike market when the supply from the more southern growers is in greatest abundance and the price somewhat depressed.

The forcer of asparagus under glass, etc., has been able to supply the demand for high-priced asparagus in our large cities, though of course at an expense much greater than that which the outdoor grower incurs; so, all things considered, it is really the medium early but prolific bearer of larger spears which comes nearer to the requirements of even the average Southern grower. Canned asparagus, too, is on the market all during the winter season, and as the product of the cannery more nearly resembles the fresh article than most canned vegetables the demand for it is very good.

There are large areas of asparagus whose growers contract to deliver all their product to the cannery at a fixed price per bunch, and for these growers the early variety has no attractions, unless all growers plant it, as the cannery only begins operations at a time when experience has shown that asparagus may be expected to be had in considerable quantities.

From early in March until July outdoor-grown asparagus is on the market, the earliest coming from our Southeastern seacoast and the latest from New England and northwestern New York, with the different intermediate localities sending in their quota some time during this period.

Six weeks from date of beginning to cut, or perhaps, if the bed is very vigorous, eight weeks therefrom, one should cease cutting and permit the succeeding shoots to develop, that the roots may have a chance to recuperate for the next season's crop. Young beds, however, are not cut for market until the second spring after having been set out, and then only a light harvest should be made, lasting perhaps



FIG. 3.—Knife for cutting asparagus.

three weeks, as the roots will not stand a full harvest of six or eight weeks before they are five years old without suffering permanent injury.

If green asparagus is desired, the stalks need be cut only so far beneath the surface as to furnish a 9 or 10 inch spear, the major part of which, say 6 inches or more, will be green, and of course above ground. If white asparagus is sought for, the rows will have been ridged from 10 to 15 inches above the crowns, and the spears must be cut as soon as they show at, and before they peep above, the surface. This means cutting 9 or 10 inches below the surface. To accomplish this, long chisellike knives of various shapes are used, the most common kind in use being shown in fig. 3. These knives are from 12 to 15 inches long, and the cutting edge is on the end.

Cutting should be done at least every day, and when vegetation is rapid twich each day will be necessary for white asparagus, and is often desirable when the green sort is being cut.

In many European beds a knife is never used, the following being the method used:

The slightly hardened crust around the emerging bud is pushed aside. The fore and middle fingers, separate, are then pushed deeply into the soft mound, pushing the earth outward. If a rising shoot be met with on the way down, it is carefully avoided. A second plunge of the two fingers and pushing out of the earth usually bring them to the hardened ground about the crest of the root. The forefinger is then slipped behind the base of the shoot and pushed gently outward, when the shoot at once snaps clean off at its base. This plan has the advantage of leaving no mutilated shoots or decaying matter in the ground. The earth is loosely and gently raked up with the hand, so as to leave the surface of the mound (ridge) as it was before, care being taken not to press the earth in any way, but to keep it quite friable. The shoots are not rubbed or cleaned in any way. It would disfigure them, and they do not need it.

In this country the cutting is usually done by men, who, passing along between the rows, carefully cut all discoverable spears, if white asparagus is being put up, or, if green, all those which are in proper condition and which by cutting 2 or 3 inches below the surface will be long enough for market.

The manner of cutting is to take hold of the end of the spear with the left hand, insert the knife to the desired depth, carefully avoiding other spears, and sever the spear if possible with one downward stroke, at the same time drawing out the severed spear and dropping it into a basket carried for that purpose. An active farm hand, after a little practice, should be able to cut several hundred bunches per day.

The spears are sorted into extras, primes, and seconds, ranging from 10 to 50 spears to the bunch, there being no difference in the diameter, but considerable in weight of the bunches. Of course the large, fine spears sell highest, but to the cultivated taste the moderate-sized but tender spears found in primes are preferable.

The bunching is done in the barn or in a shed, and the operators are

usually women. Patent bunchers (fig. 4) are used, each holding tightly a bunch of the proper size while it is being tied at each end with jute twine or sisal grass, so that it will retain its shape. The spears are placed with the heads all one way, and the butts are cut off evenly with a sharp knife. Some skill is needed to put up bunches rapidly;

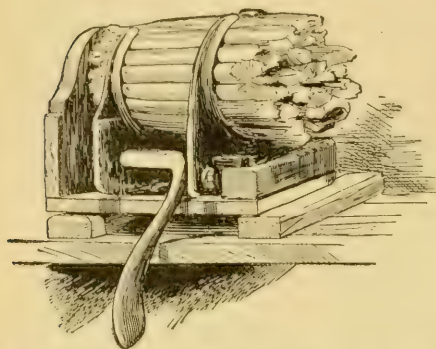


FIG. 4.—Asparagus buncher and bunch of spears ready to be tied.

but it is work that can be done by anyone, the only requisite being to so arrange the spears that the bunch shall present a good appearance and the spears be somewhat uniform in size.

Packing for shipment is frequently done very carelessly, and all kinds of nondescript packages are to be found in market. This may not entail serious loss in the case of nearby shippers or of those who take their asparagus to market in wagons; but to ship

to market in any but the best and most carefully put up package is to sacrifice a price which sometimes amounts to all the profit. The writer has seen asparagus in the market packed in soap boxes, strawberry crates, solid and slatted crates built to hold several dozens, and the bunches placed on their sides, on end, one on top of the other, etc.—any way to get them in.

Perhaps the crate known as the Southern package is as good as any for shipping. These are built to hold from 2 to 3 dozen bunches set on the big end on moist moss to preserve their freshness.

The box holding

30 bunches, $4\frac{1}{2}$ inches in diameter, is of the following dimensions: Twenty-eight inches long, 22 inches wide, and 9 inches deep, outside measurement. It is made as follows: Ends $\frac{3}{4}$ inch thick, slats $\frac{3}{8}$ inch by $4\frac{1}{2}$ inches wide, and the cost is about \$12.50 per hundred boxes. The box holding 2 dozen bunches of green asparagus, shown in fig. 5, all ready for shipment, with the exception of 3 slats still to be nailed on, is of the following dimensions: Twenty-four by 17 inches by 12

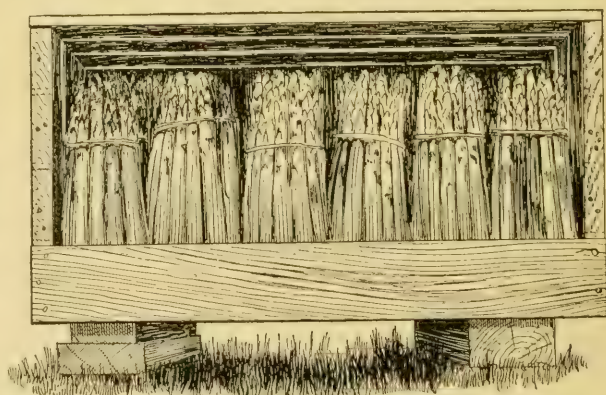


FIG. 5.—Box containing 24 bunches of green asparagus.

inches, and the top is some 3 inches narrower than the bottom, thus holding the bunches more firmly, as they, being smaller at the top, are often shaken about and bruised in the straight-sided boxes. These are made of different heights to accommodate long or short bunches, but as there is often a premium, sometimes equal to all expenses of shipping, on long bunches, it is wise to provide for full-length bunches, especially when shipping green asparagus. Figs. 6 and 7 show 2 long bunches of green asparagus (side and end views), 1 bunch containing 11 spears and weighing $2\frac{1}{2}$ pounds, and the other 25 spears and weighing 3 pounds. The first is an "extra" and the other a "prime."

Figs. 8 and 9 show four bunches of white asparagus cut for a cannery on Long Island, and classed as primes. The box on which they stand is 14 inches wide and the bunches $8\frac{1}{2}$ inches long.

When shipped long distances these packages should go by express, as the time even fast freight consumes will prove injurious to asparagus.

Bunches which have to be kept for a day or more, or even over night, should either be packed in sand in a cool cellar or set with their butt ends in shallow (1 inch deep) pans of water.

The yield per acre and price per bunch have a decided effect upon the profit and loss point of view. The canners who this year (1897) paid 10 cents a bunch for prime asparagus or 4 cents for culls paid prices which satisfied growers, although in the city markets prices were somewhat higher than usual, as the cool spring made the crop late even if it did not lessen the yield. The contractors, of course, took all asparagus offered, and the growers found it more profitable than shipping to city markets.

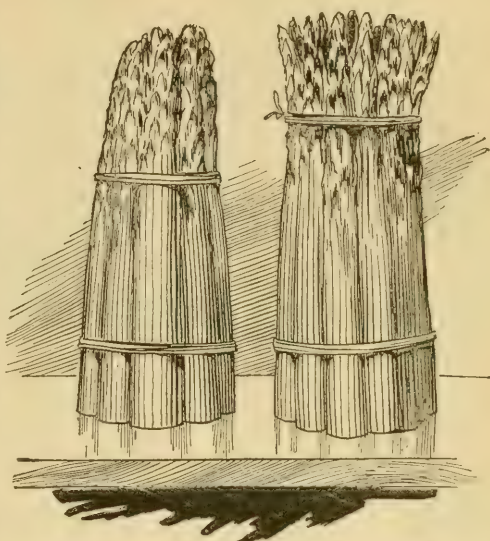


FIG. 6.—Two bunches of green asparagus (10 inches long, with 11 and 25 spears, respectively).

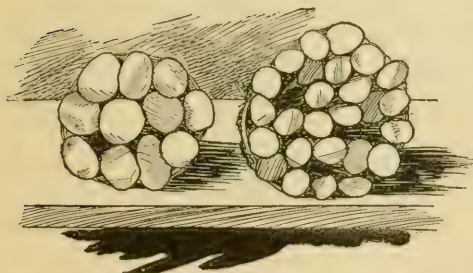


FIG. 7.—End view of the two bunches of green asparagus shown in fig. 6.

By planting a late variety such as Late Purple Argenteuil, which, while not much later in appearing in the spring, bears much longer than the early varieties, or by treatment inducing a second growth during the summer (which is, however, rather exhausting to the crowns), naturally grown asparagus can be produced for market until midsummer.

In addition to this, by forcing the beds or the roots removed from the beds to hothouses, asparagus can be supplied continuously from December until early spring, when the open beds begin again to produce.

FIG. 8.—Four bunches prime white asparagus (8½ inches long, averaging 30 spears to the bunch, weight 2 pounds).

In Europe, owing to the trend of the country, the season of fresh asparagus is much shorter than in this country, and for that reason, perhaps, forcing has been more widely practiced.

The London market has been a great consumer of the forced article, and the local market gardeners are largely engaged in supplying the demand. But this

business is by no means more extensively followed by the London than by the continental gardeners. As an example of the extensiveness of this industry in France, reference is made to one farm at Saint-Ouen, on which 67 acres are devoted to growing asparagus crowns to be

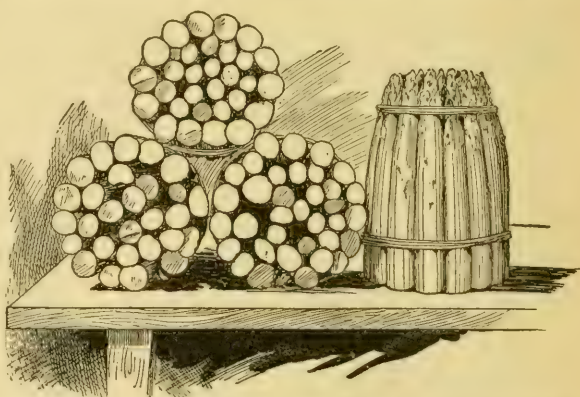


FIG. 9.—End view of three of the four bunches of prime white asparagus shown in fig. 8.

forced for the winter market, and there are numerous growers engaged in supplying the Paris demand for hothouse asparagus. This industry is also extensively carried on near the large cities of the United States, among which Boston is perhaps the best market for forced asparagus.

CANNING AND DRYING.

The preserving of asparagus for use at a time when fresh asparagus is not available has been practiced many years by thrifty housewives both in Europe and in this country.

CANNING.

It is not in the province of this bulletin to attempt a description of asparagus canning as practiced in a factory; for such at best would be the detailing of the method practiced at one and might differ widely from the practice of every other, and besides it is a business requiring expert knowledge and considerable capital, while domestic canning of asparagus is as simple as for any fruit or other vegetable.

In Austria, Germany, Sweden, and France canned asparagus is a frequent dish. In England "tinned" asparagus seems not to have gained a foothold, although it is not unknown, and California and Long Island "tinned" asparagus are receiving favorable recognition in London.

A lady of experience as a housekeeper gives the following recipe:

Cut the asparagus the length of a fruit jar, pack the jar closely, fill with cold water, add a little salt, and put the lid on loosely. Place these jars in hot water reaching to the brim, and boil for three hours, adding enough hot water to that in the jars to keep them full. Close lids tightly and set jars away to cool.

Of course the tough outer scale should be removed and the spears carefully washed prior to being placed in the jars; the butt ends should all be placed down, and there should be as little space as possible left at the top. Two hours may be long enough to boil the asparagus, but less than that would scarcely be a full substitute for the several steam baths to which asparagus is subjected in canneries.

Many growers collect the spears broken by the harrow used in leveling off the beds after the cutting season and, putting these with the proceeds of the last cutting, have them canned by the factory for home use, the factory charging them only the actual cost of doing the work. The last day of the season is at most canneries devoted to this kind of work for their patrons. In this way, at a trifling cost, an excellent vegetable is provided for the table during the winter.

To prepare the contents of the can for table, be it home or factory filled, open carefully, pour off the liquid, and either place the asparagus in boiling water for a few minutes (it has already been cooked and only needs to be heated) or set the open can in boiling water until ready to serve on the table, when it is placed on a dish and the desired dressing is added.

DRYING.

For drying, the medium-sized spears are probably, all things considered, the best (although even the small spears may be used for flavoring soups and sauces), but if thoroughly dried so that they will keep,

the large thick stalks are delicious for the table. Perhaps it would be an equitable division to can the largest and dry the others.

In drying use a large needle and strong thread (small twine will do). Pass the thread through the butt end of each stalk, forming a string of a size convenient for handling; this string of stalks is then hung along the exposed side of the house in the full light of the sun. In case the string is not completely dried during the day it is removed to a dry room at night; the next day it is returned to its place in the sunlight

until fully dried. It is then put away in a bag of some porous material, in a dry place, until needed.

When desired for use take a sufficient number of the dried stalks and place them in water which, while not boiling, is very near the boiling point, keeping them there until they resume their succulent, smooth, fresh appearance. To keep the water just right a double boiler is best, with the stalks in the inner one. The water in the outer vessel should be kept at a steady boil.

As the stalks resume the fresh appearance, take them out carefully one by one and place in cold water until cooled, after which place on a dish to dry. They should be carefully sealed to remove the hard outside skin, done up in a bundle



FIG 10.—Stems of asparagus affected with "rust," caused by the fungus *Puccinia asparagi* DC., in which the black sori are seen occupying lines and patches on the stems. (Redrawn and reduced; from Twentieth Annual Report Connecticut State Agricultural Experiment Station.)

either by tying with strings or wrapping in a piece of netting, placed in boiling water, to which a little salt has been added, and allowed to remain there a few moments, a very few, for it cooks quickly, until done.

FUNGUS DISEASES.

Asparagus is subject to the attacks of a number of fungi, the most widespread and destructive being the rust, a fungus long known in Europe, but only recently observed here. In 1896 it caused serious

injury in parts of New Jersey and Long Island and was made the subject of study by Dr. B. D. Halsted.

When the plants are apparently in vigorous growth and full vegetation, they are attacked by this disease (*Puccinia asparagi* DC.), which appears first as small reddish-yellow points on the main stem near the ground and also on the branches and leaves, then, spreading and extending into patches and streaks, it covers the whole plant, turning at the same time to a red-brown or orange color, which later in the season becomes dark colored, and in this form it passes the winter.

As a result of the attacks of the spores the leaves fall, and the plants



FIG. 11.—Magnified spores of *Puccinia asparagi* DC.: 1, two sori of summer spores, occupying the external tissues of an asparagus stem, magnified 50 diameters; 2, portion of the same, magnified 196 diameters; 3, portion of a sorus of winter spores, magnified 196 diameters; 4, a sorus of winter spores, magnified 50 diameters. (Redrawn; from Twentieth Annual Report Connecticut State Agricultural Experiment Station.)

present a naked appearance (fig. 10). The stalks and branches are rough to the touch, granular, and furrowed. Rust attacks asparagus plants of all ages, from the seedling in the seed bed to the almost exhausted bed of many years' standing. Neither location of the bed in high or low land nor methods of cultivation seem to affect the disease to any great extent.

The earlier or later appearance of the rust is somewhat dependent upon the condition of the weather. At the beginning of a long-continued drought in July or August the rust will make its appearance, and in high, dry locations the ill effects will be more noticeable than in lower lands.

This disease is as enduring as it is dangerous to asparagus culture. It is often two or three years after an attack before the plants entirely recover. The most effectual means of controlling the disease has been by means of fire. The cutting, careful collection, and immediate burning not only of all visibly affected stalks, but of all asparagus brush, both cultivated and wild, early in the autumn are duties that each asparagus grower owes to himself and to every other grower.

In order to prevent the crowns from becoming infected the ground should be kept light and open by frequent hoeings and cultivation, and during the winter the soil should be kept free from all standing water. Extreme dampness will, without doubt, induce root decay, and that is a

favorable condition for developing the disease.

Perhaps the withholding of organic manures and substituting chemical fertilizers may assist in preventing the disease; or the addition of sand and charcoal or coal ashes will aid in keeping the plants healthy and in absorbing the overabundant winter moisture.

Spraying may do something toward checking the disease, and some standard fungicide, like Bordeaux mixture with paris green added, should be used after the cutting season is over and as soon as the foliage begins to develop; for, while



FIG. 12.—Portion of rusted asparagus stems. (Redrawn; from Report, 1896, New Jersey Agricultural Experiment Stations.)

this fungus is one which does not readily yield to treatment, some good may be accomplished, and the arsenite used will at least make the plants unwholesome food for the beetles and their larvæ.

Professor Halsted says in a circular concerning the asparagus rust, issued September 18, 1896:

When an asparagus field is badly infected with the rust, the general appearance is that of an unseasonable maturing of the plants. Instead of the usual healthy green color, the field has a brownish hue, as if insects had sapped the plants or frosts had destroyed the vitality. Rusted asparagus plants, when viewed closely, are found to have the skin of the stems, both large and small, lifted as if blistered, and in the ruptures of the epidermis dark-brown spots are readily seen. These brown dots or lines are of various sizes and shapes, and remind the close observer of similar spots in the broken skin of stems of grains and grasses and of the leaves of corn attacked by rust, but not the same kind as that of asparagus.

The asparagus rust is due to fungus; that is, a minute plant (fig. 11), consisting of

microscopic threads which grow through the substance of the asparagus plant, taking up the nourishment that is needed (by the plant itself) and finally breaking through the surface to bear the innumerable brown spores that give the dark-brown color to the spots on the asparagus skins. This is the last stage in the development of the rust fungus, and as such it remains over winter. When the warm, moist weather of spring and summer comes, the spores above mentioned germinate, and a new lot of asparagus plants may become infected.

In the Botanist Report of the New Jersey Experiment Stations for 1896, Professor Halsted has, among other remarks, this to say about the asparagus rust attack of that year:

The writer has never met with any species of rust that was so overwhelming in its attack. Fields, for example, of a dozen acres would not have a plant, and scarcely a square inch of surface, free from the pustules. It attacks all ages of plants, but



FIG. 13.—The asparagus anthracnose (*Colletotrichum* sp.). (Redrawn; from Report, 1896, New Jersey Agricultural Experiment Stations.)

the older beds turned brown first, and the last to lose their usual green color were the seedlings. The brush is reduced to the main stems, the finer portions having become thoroughly affected and fallen away. Portions of stems of older plants are shown in fig. 12, where the rifts in the skin may be seen and the spore masses appear as dark blotches.

All varieties of asparagus grown in this country seem to be readily affected by the rust, the Palmetto being less susceptible than any others. Professor Halsted places it at 60 on a basis of 100. Claim is also made by European growers that the Yellow Burgundy is almost rust proof.

The rust has been reported from New England generally, Long Island, New Jersey, Delaware, Maryland, the District of Columbia, Iowa, Indiana, Ohio, and South Carolina. From the interest taken in the

subject by the growers, who are promptly adopting the suggestions made as to burning, etc., it is doubtless true that had it been elsewhere in any quantity reports of its presence would have been made.

According to Massachusetts Hatchery Experiment Station Report, 1899, p. 61, there appears to be a relationship between the water-retaining properties of the soil and the occurrence of rust, the disease being most prevalent upon light sandy soils. Spraying the plants with Bordeaux mixture has been tried with some apparent success in controlling the disease, and in New York Station Bulletin 188 spraying with Bordeaux mixture to which has been added 5 pounds resin, 1 pound potash lye, 1 pound fish oil, and five gallons water is recommended. A number of parasitic fungi are known to attack the asparagus rust and aid materially in keeping it in check.

Other diseases due to fungi are known to attack asparagus plants, among which an anthracnose (*Colletotrichum* sp.) is by no means insignificant, and its effect upon the stalk of asparagus consists of multitudes of minute dark specks, shown in fig. 13. In Europe a fungus, known as *Sclerotium durum* Pers, attacks the old stalks, and another, known as *Cereospora asparagi* Saccardo, forms gray specks on the green branches of asparagus; still another, the copper-red thread fungus, attacks the roots, and is familiarly known as the "root killer."

INSECT ENEMIES.

By F. H. CHITTENDEN, *Assistant Entomologist.*

The principal insect enemies of asparagus are two beetles, both imported from the Old World, and both, so far as known, limited for food supply to this plant. A third insect, known as the asparagus fly (*Platyparea pascioptera* Schrk.), is also injurious to asparagus in Europe, but it has not yet been detected in this country, and is only mentioned that American asparagus growers may be on their guard against it, as it is a species that is liable at any time to be brought to our shores.

THE COMMON ASPARAGUS BEETLE.

(*Crioceris asparagi* Linn.)

This species, as its common name indicates, is still the most abundant of the asparagus beetles and by far the most important enemy of this plant. Its first appearance was noted in this country at Astoria, near New York City, in 1860, and it is now conceded that it was introduced into that locality about 1856.

The injury inflicted by this insect is due to the work of both adults and larvæ upon the tender shoots, which they render unfit for market early in the season. Later they destroy by defoliation growing plants, and are particularly injurious to seedlings, the roots of which are weakened by having their tops devoured. Larvæ, as well as beetles, attack the tenderest portions of the plants, but the latter gnaw with seemingly equal relish the epidermis or rind of the stems. The beetles

are also accused of gnawing young shoots beneath the surface, causing them to become woody and crooked in growth.

The beetle illustrated by fig. 14 is a most beautiful creature, slender and graceful in form, blue-black in color, with red thorax, and lemon-yellow and dark-blue elytra or wing covers, with reddish border. Its length is a trifle less than one-fourth of an inch.

From the scene of its first colonization in Queens County the insect migrated to the other truck-growing portions of Long Island. It soon reached southern Connecticut, and has now extended its range northward through that State and Massachusetts to the State line of New Hampshire. Southward it has traveled through New Jersey, where it was first noticed in 1868, to southern Virginia. At the present time it is known to be well established in the principal asparagus-growing sections of Massachusetts, Connecticut, New Jersey, Delaware, and Maryland. In Pennsylvania it is present in the southeastern portion of the State near the Delaware River, and in Virginia it extends southward along the banks of the Potomac. In New York State it occupies,



FIG. 14.—Common asparagus beetle: *a*, beetle; *b*, egg; *c*, newly hatched larva; *d*, full-grown larva; *e*, pupa—all enlarged (from Chittenden, Yearbook of U. S. Department of Agriculture, 1896).

besides Long Island, a narrow strip along the Hudson to a point about 20 miles north of Albany, and it has very recently made its appearance in four counties in the northwestern section of the State. In Ohio it has found its way to four counties between Cleveland and the Pennsylvania State line.

The question of distribution is an important one, as this species is rapidly extending its range. In a very few years we may expect its spread to other portions of the States in which it is now local, and later it will naturally move westward to Indiana and other States west and south of there.

The insect passes the winter in the beetle state under convenient shelter, and toward the end of April or early in May, according to locality, or at the season for cutting the asparagus for market, issues from its hibernating quarters and lays its eggs for the first brood. The eggs are deposited endwise upon the stem or foliage and in early spring on the developing stalks, usually in rows of from two to six or more.

In from three to eight days the eggs hatch, the young larvæ, commonly called "grubs" or "worms," presenting the appearance indicated in fig. 14, *c*. They at once begin to feed, and are from ten days to a fortnight, according to Fitch and others, in attaining full growth. When full grown the larva appears as in fig. 14, *d*. It is soft and fleshy, much wrinkled, and in color is dark gray or olive, which usually becomes lighter and yellowish with age. The mature larva enters the

earth, and here, within a little rounded, dirt-covered cocoon which it forms, the pupa state is assumed. The pupa is yellowish in color and its appearance is sufficiently shown by the illustration (fig. 14, *e*.) In from five to eight or more days the adult beetle is produced, which soon issues from the ground in search of food and of a suitable place for the continuance of the species.

The duration of the life cycle, according to Fitch, is about thirty days from the time the egg is laid until the insect attains maturity, but the time is shorter in the hotter parts of a season than in the cooler days of May or September. In the District of Columbia the eggs, in the warmest part of midsummer, develop in three days and the pupæ in five days. From this it may be estimated that, in the very warmest weather, the development of the insect may be effected in about three



FIG. 15.—Spray of asparagus, with common asparagus beetle in its different stages; asparagus top at right, showing eggs and injury—natural size (from Chittenden, Yearbook of U. S. Department of Agriculture, 1896).

weeks from the time the egg is laid. In colder climates and in spring and autumn the development from egg to beetle will require from four to perhaps seven weeks. In the northern range of the species two and perhaps three broods are usually produced, and farther southward there is a possibility of at least a fourth generation. In the latitude of the District of Columbia the beetles usually disappear to enter into hibernation in the latter days of September.

The common asparagus beetle has very efficient checks in the shape of predaceous insects, which prey upon its larvæ and assist in

preventing its undue increase. One of the most active of these predaceous insects is the spotted ladybird (*Megilla maculata* DeG.), represented in its several stages in the illustration (fig. 16). The adult of this beetle is rose colored, with numerous black spots. The spined soldier bug (*Podisus spinosus* Dall.) and the bordered soldier bug (*Stiretrus anchorago* Fab.) are also useful as destroyers of asparagus-beetle larvæ, which they catch and kill by impaling them upon their long beaks and sucking out their juices. Certain species of wasps and small dragon flies also prey upon the larvæ.

Asparagus beetles are very susceptible to sudden changes of temperature, and immense numbers of hibernating beetles are sometimes killed in winter during severe cold spells following "open" weather.

Remedies.—The common asparagus beetle, under ordinary circumstances, may be held in restraint by the simplest means.

Chickens and ducks are efficient destroyers of the insect, and their services are often brought into requisition for this purpose.

A practice that is in high favor among prominent asparagus growers is to cut down all plants, including volunteer growth, in early spring to force the beetles to deposit their

eggs upon new shoots, which are then cut every few days before the eggs have time to hatch. Another measure of value consists in permitting a portion of the shoots to grow and serve as lures for the beetles. Here they may be killed with insecticides, or the plants after they become covered with eggs may be cut down and burned, and other shoots be allowed to grow up as decoys.

One of the best remedies against the larvæ is fresh, air-slaked lime dusted on the plants in the early morning while the dew is on. It quickly destroys all the grubs with which it comes in contact.

The arsenites, applied dry in powder mixed with flour, answer equally well, and they possess the advantage of destroying beetles as well as grubs, and are of value upon plants that are not being cut for food. Some of our correspondents use a mixture of paris green and air-slaked lime, or plaster, 2 pounds of the former to a barrel of the latter. It should be borne in mind that to produce satisfactory results the lime or arsenite must be applied at frequent intervals, or as often as the larvæ reappear on the beds.

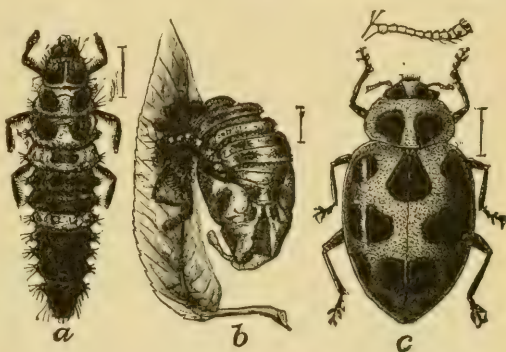


FIG. 16.—Spotted ladybird; a, larva; b, empty pupal skin; c, beetle with enlarged antenna above—all enlarged (from Chittenden, Yearbook U. S. Department of Agriculture 1896).

A simple method of killing the larvæ in hot weather is to beat or brush them from the plants with a stick so that they will drop to the heated earth, where they die, being unable to regain the shelter of the plants.

With concerted action in following out any of these methods the insects may be held in check, at least in regions where asparagus does not grow wild in too great profusion.

THE TWELVE-SPOTTED ASPARAGUS BEETLE.

(*Crioceris 12-punctata* Linn.)

The presence of this insect in America was first detected in 1881, and it is still much rarer and consequently less injurious than the preceding species. In Europe, where it is apparently native, it is common, but not especially destructive.

The chief source of damage from this species is from the work of the hibernated beetles in early spring upon the young and edible asparagus shoots. Later beetles, as well as larvæ, appear to feed exclusively on the berries. The eggs are deposited singly, and, apparently

by preference, upon old plants toward the ends of shoots, which, lower down, bear ripening berries, and they are attached along their sides instead of at one end, as is the case with the eggs of the common species. Soon after the larva hatches from the egg it finds its way to an asparagus berry, enters it, and feeds upon the pulp. In due time it leaves this first berry for another one, and when full growth is

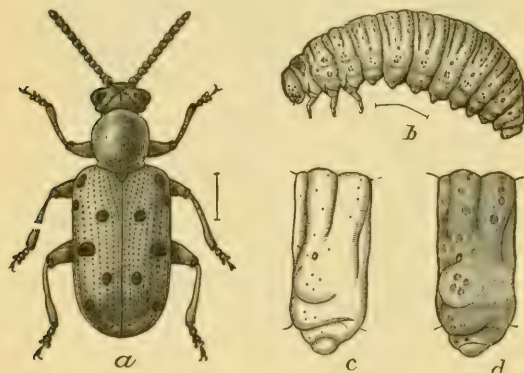


FIG. 17.—Twelve-spotted asparagus beetle: a, beetle; b, larva; c, second abdominal segment of larva; d, same of common asparagus beetle—*a, b*, enlarged, *c, d*, more enlarged (from Chittenden, Yearbook U. S. Department of Agriculture, 1896).

attained it deserts its last larval habitation and enters the earth, where it transforms to pupa and afterwards to the adult beetle. The life cycle does not differ materially from that of the common species, and there are probably the same or nearly as many generations developed.

This species is at present distributed throughout the asparagus-growing country in the southern two-thirds of New Jersey, particularly in the vicinity of the Delaware River; the whole of Delaware, nearly the entire State of Maryland, the District of Columbia, the southeastern portion of Pennsylvania bordering the State line of New Jersey, and

northeastern Virginia in the vicinity of the western shore of the Potomac River. During recent years it has been reported in Monmouth County, N. J., Staten Island and Monroe County, N. Y., the last mentioned being the most northern locality known for the species.

The mature beetle in life rivals the common asparagus beetle in beauty, but may be distinguished by its much broader wing covers and its color. The ground color is orange red, each wing cover is marked with six black dots, and the knees and a portion of the under surface of the thorax are also marked with black (see fig. 17, *a*). The beetle as it occurs on the plant when in fruit very closely resembles, at a little distance, a ripe asparagus berry.

The full-grown larva is shown in the illustration at fig. 17, *b*. It measures, when extended, three-tenths of an inch, being of about the same proportions as the larva of the common species, but is readily separable by its ochraceous orange color.

Remedies.—The remedies are those indicated for the common asparagus beetle, with the possible exception of caustic lime and other measures that are directed solely against that species, but the habit of the larva of living within the berry places it for that period beyond the reach of insecticides. The collection and destruction of the asparagus berries before ripening might be a solution of the problem, but it is questionable if recourse to this measure would be necessary, save in case of an exceptional abundance of the insect.

A more complete report on insects affecting asparagus is in preparation, and will be published in the near future in a farmer's bulletin by F. H. Chittenden, Assistant Entomologist, U. S. Department of Agriculture.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 70.

THE
PRINCIPAL INSECT ENEMIES OF THE GRAPE.

BY

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THE PRINCIPAL INSECT ENEMIES OF THE GRAPE.

That the grape is distinctively an American plant is indicated by the fact that our indigenous wild species number nearly as many as occur in all the world besides. It is not to be wondered at, therefore, that this continent is responsible also for the chief enemies of the vine, both insect and fungous, as, for example, the grape phylloxera, which, in capacity for harm, taken the world over, outranks all other vine evils together, and such blighting fungous diseases as the two mildews and the black rot. The rapid growth of the vine industry in this country and the increasing cultivation of the less vigorous European grapes make it desirable to consider briefly, from the standpoint of remedies, its leading insect enemies.

Upward of 200 different insects have already been listed as occurring on the vine in this country, and the records of the Department alone refer to over 100 different insects. Few of these, however, are very serious enemies, being either of rare occurrence or seldom numerous, and for practical purposes the few species considered below include those of real importance. They are the grape phylloxera, the grapevine fidia, both chiefly destructive to the roots; the cane-borer, destructive particularly to the young shoots; the leaf-hopper, the flea-beetle, rose-chafer with its allies, and leaf-folder, together with hawk moths and cutworms, damaging foliage, and the grape-berry moth, the principal fruit pest.

The extent of the loss that frequently results from these insects may be understood by reference to a few instances. The phylloxera when at its worst had destroyed in France some 2,500,000 acres of vineyards, representing an annual loss in wine products of the value of \$150,000,000, and the French Government had expended up to 1895 in phylloxera work over \$4,500,000 and remitted taxes to the amount of \$3,000,000 more. The grapevine fidia, on the authority of an Ohio correspondent, in a single season in one vineyard killed 400 out of 500 strong 5-year-old vines. The prominent leaf defoliators, as the rose-chafer and flea-beetle, frequently destroy or vastly injure the crop over large districts, and the little leaf-hopper, though rarely preventing a partial crop, is so uniformly present and widely distributed as to probably levy a heavier tribute on the grape in this country than any other insect.

These insects are, however, all amenable to successful treatment, and the loss may be very considerably limited if the proper methods of control are followed out. There are no remedies which apply generally to grape insects except the highly important considerations of clean culture and particularly the prompt collection and burning of prunings and leaves in the fall. The latter will very materially check most of the leaf insects and the cane-borer. Other remedies are particularized under each species.

THE GRAPEVINE PHYLLOXERA.

(*Phylloxera vastatrix* Planch.)

This insect has always existed on our wild vines, yet it was not until it had been introduced abroad and began to ravage the vine-

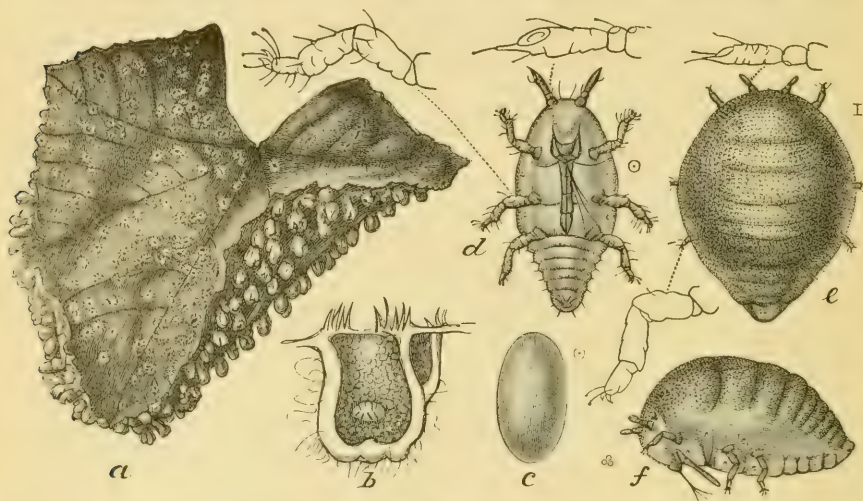


FIG. 1.—*Phylloxera vastatrix*. a, leaf with galls; b, section of gall showing mother louse at center with young clustered about; c, egg; d, larva; e, adult female; f, same from side—a natural size, rest much enlarged (original).

yards of the Old World that particular attention was drawn to it as a vine pest, or that anything definite was known of its habits. It appears in two destructive forms on the vine, the one forming little irregular spherical galls projecting from the underside of the leaves and the other subsisting on the roots and causing analogous enlargements or swellings. The leaf form is the noticeable one and is very common on our wild and cultivated vines. The root form is rarely seen, but is the cause of the real injury done by this insect to the vine, and while hidden and usually unrecognized, its work is so disastrous to varieties especially liable to attack that death in a few years is almost sure to result. It first produces enlargements or little galls on the rootlets. As it extends to the larger roots these

become swollen and broken, and finally the outer portion decomposes and rots, and the roots ultimately die. With the multiplication of the root lice and their extension to all parts of the root system, the vine stops growing, the leaves become sickly and yellowish, and in the last stages the phylloxera disappears altogether from the decomposed and rotting roots, and the cause of death is obscure to one not familiar with the insect. Many cases of death ascribed to drought, overbearing, winterkilling, etc., are undoubtedly due to the presence of the root louse.

The abundance of galls on the leaves is not an indication of the presence of the root louse in any numbers, but, in fact, the reverse of this is usually true; while on the other hand the destructive abundance of the lice on the roots is often, if not usually, accompanied by little, if any, appearance of the leaf form. This is particularly noticeable with the European grapes, which are very susceptible to phylloxera and rapidly succumb to it, yet rarely show leaf galls.

American grapes, on the contrary, are generally very resistant to the root form, and yet are especially subject to the leaf-gall insect. Certain varieties, as the Clinton, which are most resistant to the former, are especially subject to the latter.

Distribution.—The phylloxera was carried to France about 1859, on rooted American vines, and has since spread through the principal

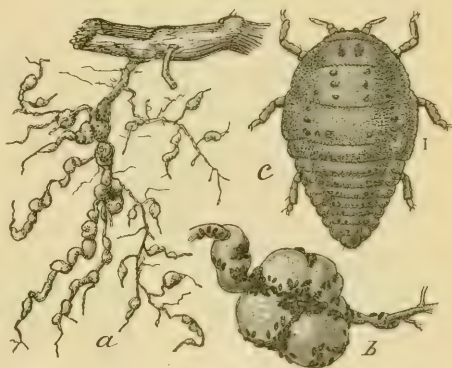


FIG. 2.—*Phylloxera vastatrix*. *a*, root galls; *b*, enlargement of same showing disposition of lice; *c*, root gall louse—much enlarged (original).

vine districts of southern Europe, extending also into Algeria and through southern Russia into the adjoining countries of Asia. It has also been carried to New Zealand and south Africa. In this country it was at first known only in the region east of the Rocky Mountains, but was soon after found in California, where, however, it is confined practically to the vine districts of the Napa and Sonoma valleys.

Life history and habits.—The life cycle of the phylloxera is a complicated one. It occurs in four forms in the following order: The leaf-gall form (*gallicola*), the root or destructive form (*radicicola*), the winged or colonizing form, and the sexual form. The leaf-gall insect produces from 500 to 600 eggs for each individual, the root-inhabiting insect not much above 100 eggs, the winged insect from 3 to 8, and the last or sexed insect but 1 egg. This last is the winter egg and may be taken as a starting point of the life cycle. It is laid in the fall on old wood, and hatches, the spring following, into a louse,

which goes at once to a young leaf, in the upper surface of which it plants its beak. The sucking and irritation soon cause a depression to form about the young louse, which grows into a gall projecting on the lower side of the leaf. In about fifteen days the louse becomes a plump, orange-yellow, full-grown, wingless female, and fills its gall with small yellow eggs, dying soon after. The eggs hatch in about eight days into young females again, like the parent, and migrate to all parts of the vine to form new galls. Six or seven generations of these wingless females follow one another throughout the summer, frequently completely studding the leaves with galls. With the approach of cold weather the young pass down the vines to the roots, where they remain dormant until spring. The root is then attacked and a series of subterranean generations of wingless females is devel-

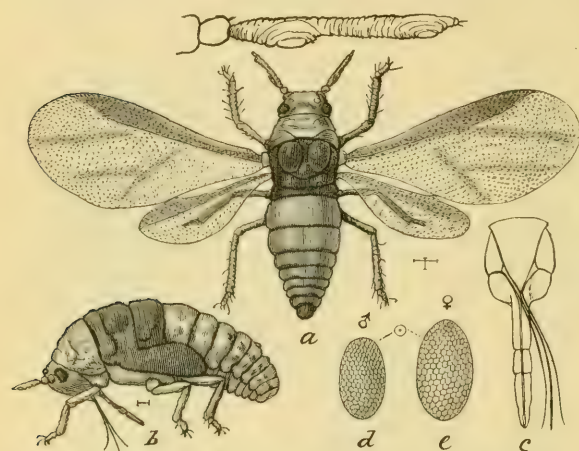


FIG. 3.—*Phylloxera vastatrix*. *a*, migrating stage, winged adult, *b*, pupa of same lateral view; *c*, mouth-parts with thread-like sucking setae removed from sheath; *d* and *e*, eggs showing characteristic sculpturing—all enlarged (original).

oped. The root form differs but slightly from the inhabitant of the leaf galls, and the swellings or excrescences on the roots are analogous to those on the leaves.

During late summer and fall of the second year some of the root lice give rise to winged females which escape through cracks in the soil on warm bright days and fly to neighboring

vines. These winged lice lay their eggs within a day or two in groups of two or four in cracks in the bark or beneath loose bark on the old wood of the vine and die soon after. The eggs are of two sizes, the smaller and fewer in number yielding males in nine or ten days, and the larger the females of the only sexed generation developed in the whole life round of the insect. In this last and sexed stage the mouth-parts of both sexes are rudimentary, and no food at all is taken. The insect is very minute and resembles the newly hatched louse of either the gall or the root form. The single egg of the larva-like female after fertilization rapidly increases in size until it fills the entire body of the mother and is laid within three or four days, bringing us back to the winter egg or starting point.

This two-year life round is not necessary to the existence of the species, and the root form may and usually does go on in successive

broods year after year, as in the case with European vines, on the leaves of which galls rarely occur. Under exceptional circumstances all of the different stages may be passed through in a single year. The young from leaf galls may also be easily colonized on the roots, and it is probable that the passage of the young from the leaves to the roots may take place at any time during the summer. The reverse of this process, or the migration of the young directly from the roots to the leaves, has never been observed.

The complicated details noted above were only obtained after years of painstaking research, conducted by the late Professor Riley in this country and many careful investigators in France.

Means of dispersion.—The distribution of phylloxera is, first, by means of the winged females; second, by the escape, usually in late summer, of the young root lice through cracks in the soil and their migration to neighboring plants; third, by the carrying of the young leaf-gall lice by winds or other agencies, such as birds or insects, to distant plants; fourth, by the shipping of infested rooted plants or cuttings with winter eggs. By the last means the phylloxera has gained a world-wide distribution; the others account for local increase.

REMEDIES AND PREVENTIVES.

The enormous loss occasioned by this insect when it reached the wine districts of the Old World led to the most strenuous efforts to discover methods of control. Of the hundreds of measures devised few have been at all satisfactory in results. The more important ones are the use of bisulphide of carbon and submersion to destroy the root lice; and, as preventive measures, the use of resistant American stocks on which to graft varieties subject to phylloxera and the planting of vineyards in soil of almost pure sand.

Bisulphide of carbon.—The use of this liquid insecticide is practicable only in soils of such consistency as to hold the vapor until it acts on the root lice and yet friable enough to afford it enough penetration. It will not answer in compact clay soils, in very light sandy ones, or in soils liable to crack excessively. The liquid is commonly introduced into the soil by hand injectors at any season except that of blooming or of ripening of the fruit. Sometimes sulphuring plows are used, or the liquid is mixed with water and the soil about the vines thoroughly drenched. The great volatility of the bisulphide enables it to penetrate to the minutest roots, and the lice quickly perish. Four or five injections of one-fourth ounce each may be made to the

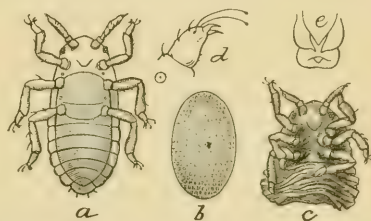


FIG. 4.—*Phylloxera vastatrix*. *a*, sexed stage-larviform female, the dark-colored area indicating the single egg; *b*, egg, showing the indistinct hexagonal sculpturing; *c*, shriveled female after oviposition; *d*, foot of same; *e*, rudimentary and functionless mouth-parts (original).

square yard over the entire surface of the vineyard, inserting the implement from 8 to 12 inches and not approaching within 1 foot of the base of the vine. The opening in the soil must be promptly closed with the foot. A large number of small doses is preferable to a few large ones. This treatment will ordinarily have to be repeated every year or two, and is therefore expensive and unsatisfactory and not to be recommended except where other means are not available.

Submersion.—Next to the use of resistant stocks, by far the best means against the phylloxera is in inundating vineyards at certain seasons of the year and for definite periods, being applicable wherever irrigation is practiced or water may be applied without too great expense. Submerging as a means against insects is a very ancient practice in southern Russia and in Greece, but was first used against phylloxera in 1868, in France, and is now practiced wherever feasible. The best results are obtained in soils which water will penetrate rather slowly. In loose and sandy soils submersion is impracticable. For this treatment vineyards are commonly divided into rectangular plats by embankments of earth, the latter protected from erosion by planting to some forage crop. As now practiced, the vines are inundated shortly after the fruit is gathered, when growth of the vines has ceased, but the phylloxera is still in full activity and much more readily destroyed than during the dormant winter season. The earlier the application the shorter the period required. During September from eight to fifteen days will suffice, and in October eighteen to twenty days, while if delayed until November a period of forty to sixty days will be needed. Copious irrigation at any time during the summer, if it can be continued for forty-eight hours, will give very considerable relief from phylloxera.

Planting in sand.—It was early observed that vines in very sandy soil were little subject to phylloxera injury, probably owing to the fact that the sand does not crack and allow the insects to escape and spread, being more thoroughly wetted with rains and subterranean moisture, and the insect is drowned out, as in submergence. The resistance is proportionate to the percentage of sand in the soil. In France vineyards are very successfully established on the sandy shores of the Mediterranean and in the alluvial sands of the valley of the Rhone and other streams.

American stocks.—The use of American vines, either direct for the production of fruit or as stocks on which to graft susceptible European and American varieties, has practically supplanted all other measures against phylloxera in most of the infested vineyards of the world. The immunity to root attack of American vines seems to be due to the thicker and denser bark covering of the roots and to greater natural vigor. All our vines are not equally resistant, and no vines are wholly immune, while several of our cultivated varieties,

as the Delaware, are almost as defenseless as European vines. Of the many wild American vines, those of chief importance as sources of stocks are the *Æstivalis*, *Riparia*, and *Labrusca*. Of these, *Æstivalis* and its cultivated varieties rank first in resistant qualities. The varieties of this species commonly grown and used for stocks are *Herbemont* and *Cunningham*. These are also very valuable on account of the superior quality of their own fruit.

The wild varieties of *Riparia* are quite resistant to the root louse, although the most subject of all vines to the attacks of the leaf-gall lice. Of the cultivated varieties, the *Clinton*, *Taylor*, *Solonis*, etc., are very commonly used as stocks. The fox grapes, derived from *Vitis labrusca*, while more resistant than European grapes, are much inferior to the other American species mentioned in this respect. *Isabella* and *Catawba*, for example, are very subject to root lice; the *Concord*, while not often seriously injured, is still rather subject to attack and therefore not so valuable as a source of resistant stocks. There are many hybrids of these and other American species, which are used either direct for their fruit or as stocks. Conditions of climate and soil will determine the particular variety to be employed, and these points can only be settled by experimental tests for new localities.

THE GRAPEVINE FIDIA.

(*Fidia viticida* Walsh.)

During midsummer the leaves of grapes are frequently riddled with irregular holes by the attacks of a little beetle which, when disturbed, falls to the ground with its legs folded up against its body, feigning death or "playing possum." The beetle is about a quarter of an inch long, rather robust, and of a brown color, somewhat whitened by a dense covering of yellowish-white hairs. In the nature and amount of the injury it does at this stage it resembles the rose-chafer, for which it is sometimes mistaken. Following the injury to the foliage, the vines may be expected, if the beetles have been abundant, to present a sickly appearance, with checking of growth and ultimate death, due to the feeding on the roots of the larvæ, for, as in the case of the phylloxera, the root injury is much more serious than the injury to foliage. Vines sometimes die after having developed half their leaves, or may survive until the fruit is nearly mature.

This insect occurs very generally in the Mississippi Valley States, from Dakota to Texas, and more rarely east of the Alleghanies and southward to Florida. The beetle has caused serious damage to foliage, notably in Missouri, Illinois, and Ohio, having been recognized over thirty years ago in the first-mentioned State as one of the worst enemies of the grape. The work of the larvæ has been recognized only recently by Mr. Webster and others in northern Ohio, but it may be looked for wherever the beetle occurs.

Life history.—The life history as worked out by Mr. Webster is briefly as follows: The yellowish eggs in large batches are thrust in cracks of the bark of the old wood, usually well above ground, as many as 700 having been counted on a single vine. Very rarely are they placed in cracks in the soil about the base of the vine, but so loosely are they attached to the bark that they not infrequently fall to the ground. The larvæ, on hatching, fall clumsily to the ground, and quickly disappear in cracks in the soil, chiefly near or just at the base of the vine. They feed at first on the fibrous roots near the point of entrance, but soon reach the larger roots, and completely denude them of bark, gradually extending outward through the soil

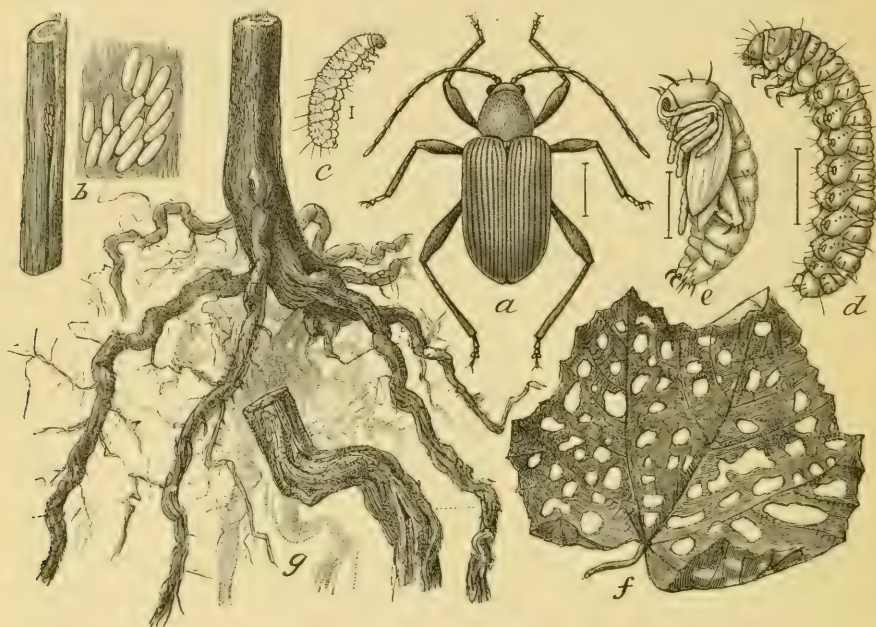


FIG. 5.—*Fidiviticida*. a, beetle; b, eggs represented natural size under fold of bark and much enlarged at side; c, young larva; d, full-grown larva; e, pupa; f, injury to leaf by beetles; g, injury to roots by larvæ—b (in part) and f and g natural size, rest much enlarged (original).

to a distance of at least 3 feet, and downward to a depth of at least 1 foot. Most of them reach full growth by the middle of August, attaining a length of nearly half an inch, and construct little cavities or earthen cells in the soil, in which they hibernate until June of the following year, when they change to pupæ.

The beetles emerge about two weeks after pupation, and begin to feed from the upper surface of the leaves. With thin-leaved grapes they eat the entire substance of the leaf, but with thick-leaved varieties the downy lower surface is left, giving the foliage a ragged, skeletonized look. They feed on any cultivated grape, also on the wild grapes, which have probably been their food from time immemorial.

Most of the adults disappear by the first of August, a few scattering individuals remaining until the first of September.

Remedies and preventives.—It is evident that if the beetle can be promptly exterminated the injury to the foliage will be limited, and the subsequent much greater damage by larvæ to the roots avoided. The first effort, therefore, should be to effect the killing of the beetles, which may be done by the use of an arsenical spray, with lime, applying it at the customary strength of 1 pound to 150 gallons of water. The feeding of the beetles on the upper surface of the leaves makes them especially easy to control by this means. If this be deferred until it is unsafe to apply an arsenical to the vines, the beetles may be collected and destroyed in the manner recommended for the rose-chaffer. The larvæ may be destroyed about the roots by injections of bisulphide of carbon made in the way already described for the phylloxera. A safer remedy, and a very effective one if applied before the end of June or before the larvæ have scattered, is to wet the soil about the vines with a solution of kerosene emulsion. The emulsion should be diluted nine times, and a gallon or two of the mixture poured in a basin excavated about the base of the vine, washing it down to greater depths an hour afterwards with a copious watering.

THE GRAPE CANE-BORER.

(*Amphicercus bicaudatus* Say.)

The young shoots of the grape during the spring months in some districts will often be observed to suddenly break off or droop and die, and if examination be made a small hole will be found just above the base of the withered shoot, with a burrow leading from it a short distance into the main stem. Within the burrow will be found the culprit in the form of a peculiar cylindrical brown beetle about half an inch long. This beetle has long been known as the apple twig-borer, from its habit of boring into the smaller branches of the apple in the manner described for the grape. It also sometimes similarly attacks pear, peach, plum, forest and shade trees, and ornamental shrubs. To the grape, however, it is especially destructive, and the name "grape cane-borer" is now given to it as more appropriate. Much complaint of this beetle is always received during the winter and early spring. Frequently all the new growth is killed, and in some cases vines have been entirely destroyed. It is extremely common in the States bordering the Mississippi, from Iowa to Arkansas, and also in Texas, often becoming throughout this region the most important insect enemy of the vine. It also occurs eastward to the coast, but rarely causes much damage in its eastern range.

It breeds in dying wood, such as large prunings, diseased canes, and also in dying or drying wood of most shade and fruit trees. It has been found by the writer breeding very abundantly in roots of up-rooted maples and in diseased tamarisk stems. In old, dry wood it

will not breed, so far as is known, nor in vigorous live growth, but seems to need the dying and partially drying conditions mentioned. The insect has but one brood yearly. The beetles mature for the most part in fall, and generally remain in their larval burrows until the following spring. A few may leave the burrows in the fall and construct others in the twigs of apple or other plants in which to hibernate. In the spring, however, they begin their destructive work early, burrowing into the axils of the grape and occasionally also into other plants. This is undoubtedly partly for food, but seems largely

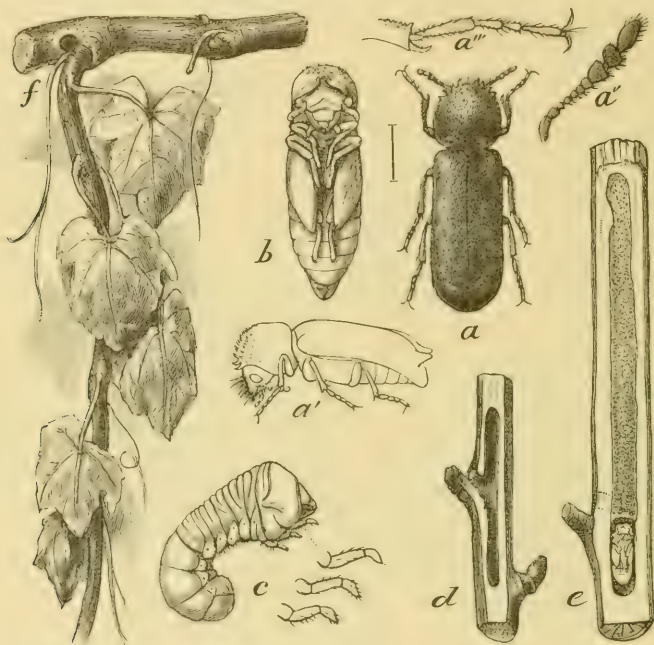


FIG. 6.—*Amphicerus bicaudatus*. *a*, beetle, dorsal and lateral view; *b*, pupa from beneath; *c*, larva from side, with enlargements of the thoracic feet; *d*, burrow in apple twig made by adult; *e*, larval gallery in tamarisk, with pupa in cell at end; *f*, injury to young shoot and cane, showing the entrance to burrow of beetle near *f* and the characteristic wilting of the new growth—all much enlarged except *d*, *e*, and *f* (original).

malicious, for it certainly has nothing to do with egg laying, although it may have some connection with the marital relation. The eggs are laid chiefly in May, or as early as March or April in its southern range, and the larvae develop during summer, transforming to pupae and beetles in the fall.

On the Pacific Coast a closely allied but somewhat larger species (*Amphicerus punctipennis* Lec.) breeds in grape canes and other plants, and probably has similar burrowing habits in the adult stage.

Remedies.—It will be apparent at once that to limit the work of this insect it will be necessary to promptly destroy all wood in which it will breed. This means the careful removal and burning of all dis-

eased wood and prunings at least by midsummer, thus destroying the material in which the larvæ are probably undergoing their development. If precautions of this sort are neglected and the beetle appears in the vineyard in spring, the only recourse is to cut out by hand every affected part and destroy the beetles. On warm days they may sometimes be collected in numbers while running about the vines.

THE GRAPEVINE FLEA-BEETLE.

(*Haltica chalybea* Ill.)

A little, robust, shining blue, or sometimes greenish, beetle, about one-fifth of an inch long, inclined to jump vigorously, and having greatly enlarged thighs, frequently appears on the vine in early spring, and bores into and scoops out the unopened buds, sometimes so com-

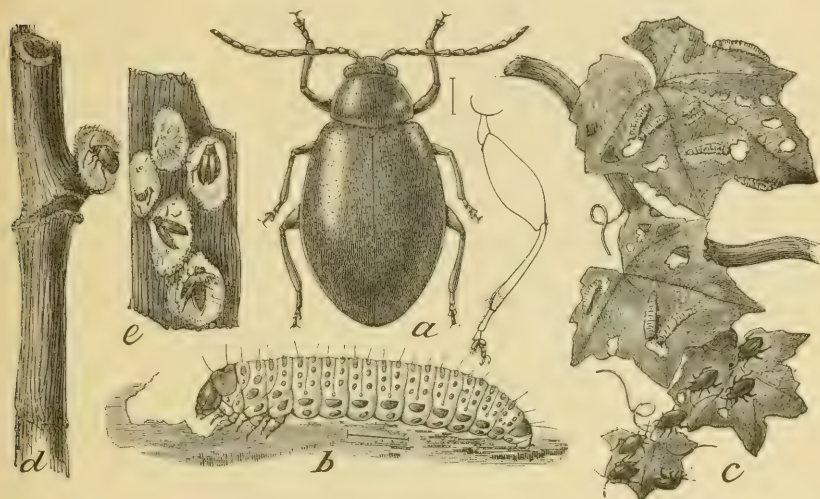


FIG. 7.—*Haltica chalybea*. a, beetle; b, larva; c, larvæ and beetles on foliage; d, injury to buds; e, beetles killed by fungus—*a* and *b* much enlarged, rest natural size (original).

pletely as to kill the vine to the roots. It attacks also the newly expanded leaves, filling them with small, roundish holes, and later deposits its orange eggs in clusters on their lower surface. Little shining brown larvæ come from these, which also feed on the leaves, and, if abundant, leave little but the larger veins. The larvæ are present for about a month during May and June, when they disappear into the ground, and transform to beetles during the latter part of June and in July. This second brood of beetles remain on the leaves through the summer, feeding a little, but doing but little damage to the vines, now in full leaf. In the fall the beetles go into winter quarters in any protection, as in cracks in fences or buildings, in masses of leaves, under bark, etc.

The grapevine flea-beetle is sometimes erroneously called thrips. It occurs throughout the United States and Canada, the time of its appearance varying with the latitude, and possibly being double-brooded in the South. It is often abundant on wild vines, and also occurs on the alder. In the spring it is, perhaps, the subject of more frequent complaint than any other grape insect.

The damage to the buds is most to be feared and the hardest to prevent. A very strong arsenical wash, say, 1 pound to 50 gallons of water, with lime, applied before or as soon as the beetles appear, will, perhaps, afford protection. Mr. Howard has found also that the beetles at this season may be successfully jarred into cloth collecting frames placed about the vines as recommended for the rose-chafer, and that if the cloth is saturated with kerosene, the beetles striking it will soon perish. Later in the season the beetles and larvæ on the foliage may be reached by an arsenical spray of the customary strength, viz, 1 pound of the poison to 150 gallons of water.

THE ROSE-CHAFER.

(*Macrodactylus subspinosus* Fabr.)

With the blooming of the grape, an awkward, long-legged, light-brown beetle about one-third of an inch in length frequently appears in enormous swarms, at first devouring the blossoms, then the leaves, reducing them frequently to mere skeletons, and later attacking the young fruit. By the end of July these unwelcome visitors disappear as suddenly as they come.

Though now distinctively a grape pest, it was first known as an enemy of the rose, whence its name, "rose-bug," or rose-chafer. It attacks also the blossoms of all other fruit trees and of many ornamental trees and shrubs, and, in fact, in periods of great abundance, stops at nothing—garden vegetables, grasses, cereals, or any green thing. At such times plants appear a living mass of sprawling beetles clustering on every leaf, blossom, or fruit.

The rose-chafer occurs from Canada southward to Virginia and Tennessee, and westward to Colorado, but is particularly destructive in the eastern and central portions of its range, notably in New Jersey, Delaware, and to a less extent in New England and the Central States.

It passes its early stages in grass or meadow land, especially if sandy—the larvæ feeding on the roots of grasses a few inches below the surface of the ground like the common white grub, which they closely resemble except in size. The eggs are laid in the ground in June and July, and the larvæ become full grown by autumn and transform to pupæ the following spring, from two to four weeks prior to the emergence of the beetles.

Remedies.—The rose-chafer is a most difficult insect to control or destroy, and the enormous swarms in which it sometimes appears make the killing of a few thousand or even millions of little practical

value. Practically all substances applied to vines to render them obnoxious to the beetles have proved of little value, but a correspondent reports having successfully protected his vineyard last summer by spraying with a wash made by diluting 1 gallon of crude carbo-lic acid in 100 gallons of water. The arsenicals are available only when the beetles are not very numerous; otherwise their ranks are constantly recruited by newcomers, and under these circumstances all insecticides, however effective ordinarily, are unavailable. When this is the case, the only hope is in collecting the beetles or in covering and protecting plants with netting, or later in bagging grapes. Advantage may be taken of their great fondness for the bloom of spiræa,

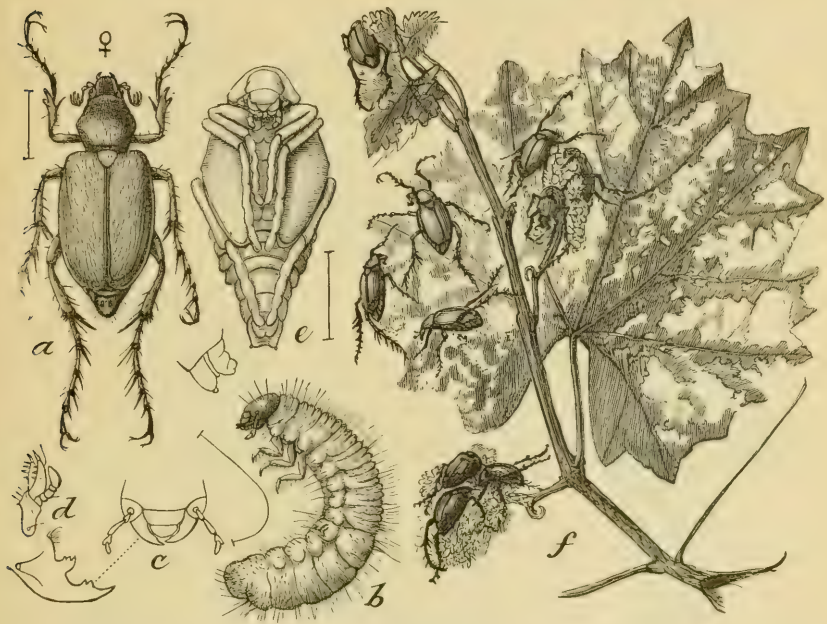


FIG. 8.—*Macrodactylus subspinosus*. a, beetle; b, larva; c and d, mouth-parts of same; e, pupa; f, injury to leaves and blossoms with beetles, natural size, at work (original).

and rows of these flowering shrubs may be planted about the vineyard to lure them and facilitate their collection.

They may be gathered from these trap plants, or the grapes themselves, in large hand beating nets, or by jarring into large funnel-shaped collectors on the plan of an inverted umbrella. The latter apparatus should have a vessel containing kerosene and water at the bottom to wet and kill the beetles.

All measures must be kept up unceasingly if any benefit is to be derived.

The numbers of the rose-chafers may be considerably limited by restricting the areas in which they may breed. All sandy meadow

land especially should be broken up and cultivated to annual crops, and the more general the cultivation of all lands the fewer will be the rose-chafers. In this procedure notable results may only be secured by the cooperation of a neighborhood.

THE GRAPE LEAF-FOLDER.

(*Desmia maculalis* Westw.)

One of the noticeable features of a vineyard, particularly in mid-summer and later, is the many folded leaves the interiors of which have been skeletonized. This is especially evident with thick-leaved varieties, the whitish under surface contrasting strongly with the dark green of the upper. If the leaf be unfolded, it will be found to contain a very active, wriggling, greenish larva, a little less than an inch long, which is apt to spring out of the fold and fall, or hang by a

thread. The leaf itself will be found to be attached to the folded part by means of numerous little cords of silk. If the larva is full grown, the interior of the leaf will be thoroughly skeletonized, and soiled with accumulated excrements. The fold almost invariably brings the upper sides of the leaf together, the larva feeding, therefore, on what would be the upper surface of the leaf. The larva transforms to a reddish-brown chrysalis usually within a much smaller fold of the edge of the leaf, but sometimes

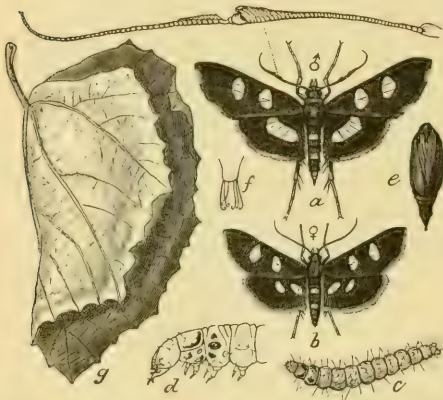


FIG. 9.—*Desmia maculalis*. a, male moth; b, female; c, larva; d, head and thoracic segment of same, enlarged; e, pupa; f, tip of pupa, enlarged; g, grape leaf folded by larva (original).

within the larger larval fold. The moth, which, during midsummer, issues in a few days, expands about an inch and is a shining opalescent black, with wings bordered with white and marked with white spots, as in the illustration (fig. 9), a slight variation in maculation being noted between the males and females. The moth is seldom seen, but if the vines be shaken it may be frightened up and observed in quick flight seeking other concealment. There are two, or, in the South, three, broods each summer, the last brood hibernating in the leaves very much as does the grape-berry moth, the pupal cases of which are very similar to those of the leaf-folder. It occurs from New England southward to Florida, and westward at least to the Rocky Mountains, and probably is distributed throughout the vine districts of the United States. It affects all kinds of grapes, showing, perhaps, a little preference for the thick-leaved over the thin-leaved varieties.

Remedies.—The appearance of a leaf folded by a larva of this insect renders its detection easy, and if the vines are gone over and the larvæ crushed in the folded leaves early in the season when they are few in number, allowing none to escape, later damage may be almost entirely prevented. If the vines are sprayed with arsenicals for other leaf-eating insects, the treatment will destroy all larvæ folding leaves soon thereafter, but not those already present. The ease with which



FIG. 10.—*Philampelus achemon*. a, moth; b, egg; c, young larva; d, mature larva; e, pupa; f, parasitized larva—all natural size (original).

this insect may be destroyed by hand makes it hardly advisable to spray for it alone, and after the grapes have become well formed later in the summer it is no longer safe to spray with arsenicals. Aside from hand picking at this time there is nothing to be done except to adopt measures which will afford protection the following year. These consist in the collection and burning of all fallen foliage as promptly as possible in autumn to destroy the hibernating larvæ and chrysalides.

HAWK MOTHS AND CUTWORMS.

The larvæ of upward of 50 moths feed on the foliage of the grape. Many of these are rare, yet many others are occasionally destructive. Aside from the leaf-folder already discussed, perhaps the leaf-feeding caterpillars oftenest the cause of important damage are the large green or brownish, usually horned, sphingid larvæ and certain cutworms.

Hawk moths.—The larvæ of some ten species of hawk moths or sphingids occur on the grape, and nearly all are widely distributed. The one most frequently met with is the Achemon sphinx (*Philampelus achemon* Drury) herewith figured (fig. 10) to illustrate the characteristics of the group. The sphinx larvæ strip a branch at a time completely, and are, therefore, easily noted. They are not often very abundant and the injury is not usually great, except in the case of young vines, which may be entirely stripped and killed by a single larva. Hand picking is ordinarily the simplest and most satisfactory remedy.

Cutworms.—The climbing cutworms have at times proved very destructive to the buds and foliage of vines, and in northern New York, and particularly in the raisin district of Fresno County, Cal., as much damage has been done by them as by any other insect enemy.

Of the several species which in different localities have been troublesome, the worst record may be assigned to the dark-sided cutworm (*Agrotis messoria* Harr.) and the variegated cutworm (*A. saucia* Hbn.), both occurring throughout the United States, and the ones chiefly concerned in the region noted in California. Cutworms remain concealed in the ground during the day and climb up and strip the vines at night. They may be easily destroyed by the use of a poisoned bait of bran, arsenic (or paris green), and water, preferably sweetened with a little sugar. It should be distributed about the base of each vine in the form of a mash, a handful or so in a place.

THE GRAPE LEAF-HOPPER.

(*Typhlocyba vitifex* Fitch.)

From midsummer to autumn, in increasing amount, the leaves of grapes are affected by a little jumping insect commonly known as the thrips, or leaf-hopper, which works in enormous numbers on the underside of leaves, causing them to appear blotched and scorched or covered with little yellowish or brownish patches, and eventually dry up, curl, and fall. This insect occurs with great regularity wherever the vine is cultivated, and yet so gradually is the damage done that, notwithstanding the great annual loss that must result to grape growers from this insect, no particular effort is ordinarily made to remedy the evil.

The depredator is a very minute insect, not exceeding one-eighth of an inch in length, and has a peculiar habit of running sidewise when

disturbed, like a crab, and dodging from one side of the leaf to the other. It jumps vigorously, like a flea, but also takes flight, rising in swarms when the vines are shaken. If examined without being too much disturbed, they will be noticed thickly clustered over the under-surface of the leaves, busily engaged in sucking the juices of the plant.

Under a lens they will be found to vary considerably in color, and, in fact, they are supposed to represent a large number of distinct species, all closely allied, however, and possessing identical habits. The prevailing color is light yellowish green, with the back and wings variously ornamented with red, yellow, and brown. In the fall they become much darker, though retaining the wing patterns. In any vineyard usually one-half dozen or more color species will occur together, one or two of which will predominate, while only a few miles distant some other forms will be the common ones. The insect figured

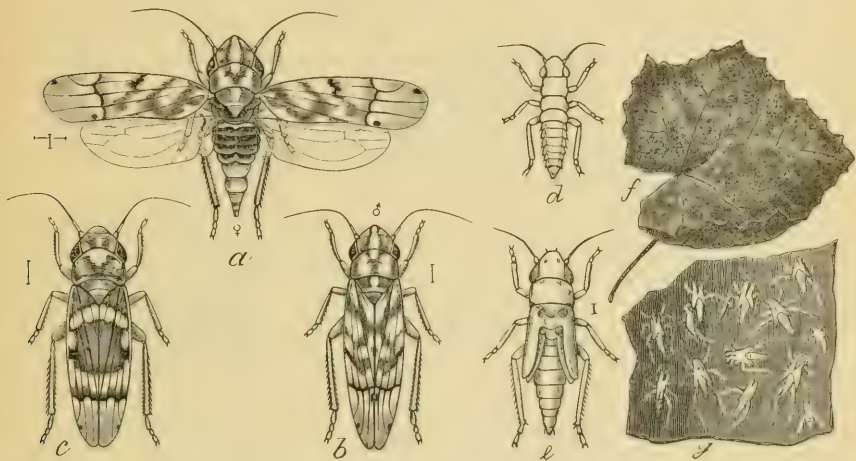


FIG. 11.—*Typhlocyba* spp. a, *T. comes* Say, female; b, *T. comes* Say, male; c, typical form of *T. vitifex*; d, larva; e, pupa; f, appearance of injured leaf; g, cast pupal skins (original).

(fig. 11) represents the most abundant species on the grounds of the Department of Agriculture in the summer of 1895, together with Fitch's original type at the right.

They begin to appear on the vines in June, and gradually increase in numbers through July, August, and September, remaining on the vines until the leaves fall, and afterwards may be frightened up in swarms from masses of leaves about the vines. The winter is passed wherever protection may be secured from storms, particularly in masses of accumulated leaves, and especially where these have been blown up against logs or fences. In such situations the writer has observed them by thousands on warm days in early winter. All varieties of grapes are attacked, the thin-leaved sorts most injuriously, but vast injury is done to all, including the wild grapes, and at least one other wild plant—the redbud or *Cercis canadensis*.

Life history.—The eggs are thrust by the female singly into the substance of the leaf on the lower side, either into the midribs and large veins or in the intervening spaces. The young are much like the adults, except that they are smaller and wingless. They cast their skins three times before becoming full grown and acquiring wings, and the white cast skins remain attached to the undersurface of the leaves, frequently upward of 100 clinging to a single leaf. In the middle and southern portions of their range they undoubtedly pass through 4 or 5 broods annually, the life of a single generation probably covering about a month.

Remedies.—The prevention of injury by the leaf-hopper is a very difficult problem. The best chances of relief will come from taking advantage of its hibernating habit and collecting and burning all fallen leaves and any similar material about the vineyards which would furnish it with winter quarters. This will be effective in proportion to the thoroughness with which it is carried out, and the treatment must be extended over a considerable area to give much relief. In this connection it must be remembered that the leaf-hoppers coming from wild grapes or from near-by vineyards are particularly apt to hibernate in woods, returning to the vineyards again the following spring.

Direct measures against this insect consist in spraying with kerosene emulsion or the use of tarred or kerosene shields. The great activity of the insect makes spraying under ordinary circumstances with caustic washes somewhat ineffective, but if the application be made in the early morning or late evening, especially if a cold or moist day be chosen, when the insects are somewhat torpid, considerable benefit will result. The emulsion should be diluted with nine parts water. Applied under the circumstances described, a great many of the leaf-hoppers will be wet with the emulsion or will fly back to the leaves and get it on their bodies before it will have evaporated. The shield method should be used in the warm part of the day, when the insects are most active. A frame with cloth stretched over it and saturated with kerosene or diluted tar may be carried along between the vine rows, the vines being agitated at the same time. The insects will fly up, and all of those striking against the screen will either adhere to the tar or get wet with the kerosene and perish. The shield method, to be effective, must be continued every day or two until relief is gained.

THE GRAPE-BERRY MOTH.

(*Eudemis botrana* Schiff.)

As the grape berries become full grown and begin to ripen, often many of them will be observed to be discolored, and if these be examined a burrow will be found eaten through the pulp from the discolored spot, and within it a whitish larva. These injured berries begin

to appear while the fruit is young and green, and as it ripens they increase in number. Frequently several of these discolored and shriveled berries will be fastened together by silken threads intermixed with the excrement of the larvæ and the sticky grape juice, the larva having passed from one to another. The appearance is not unlike that produced by black rot, and is often confused with the latter. As the larva becomes mature it changes to an olive-green or dark-brown color, and not only excavates the pulp, but burrows into the seeds of the grape. It is very active and is apt to wriggle out of the grape and escape. When full grown, the larva attains a length of about one-third of an inch, and, abandoning the grape, cuts out of a grape leaf a little flap, which it folds over and fastens with silk, forming a little oblong case, in which it changes to a chrysalis. The little slate-colored moth with reddish-brown markings on the forewings appears in ten or twelve days, drawing its chrysalis partly

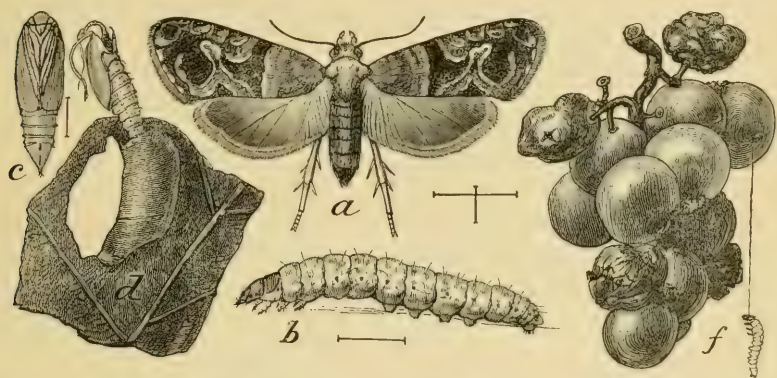


FIG. 12. —*Eudemis botrana*. *a*, moth; *b*, larva; *c*, pupa; *d*, folded leaf with pupa shell projecting from case cut from the leaf; *f*, grapes, showing injury and suspended larva, natural size—all except *f* much enlarged (original).

after it and depositing eggs for an additional brood of larvæ. The last brood of larvæ remains in the leaf cases through the winter. The moths coming from these hibernating chrysalides appear in early spring, and the first brood of larvæ lives on the leaves, tendrils, and blossoms, there being, of course, no grapes for them to infest.

This insect was imported many years ago into this country from southern Europe, where, in Austria and Italy particularly, it is very injurious and has two or three near allies which affect grape leaves and fruit in the same way, but which, fortunately, have not, as yet, been imported into this country, or if so, have not become numerous enough to be recognized. Our grape berry moth is widely distributed, occurring probably wherever the grape is grown to any extent, from Canada to Florida and westward to California. It attacks all varieties, but is especially destructive to grapes with tender skins and such as grow in compact bunches. The records of the Department

show also that this insect is a rather general feeder, and it has been bred from seed bunches of sumac and the leaves of tulip and magnolia. It sometimes enters the leaf galls of the phylloxera and eats not only the interior of the galls, but, as observed by Mr. Pergande, the young and mother louse also. It has proved particularly destructive at times in Ohio, Missouri, and Pennsylvania, and in many cases from 50 to 75 per cent of the crop has been ruined by it. It is probably three-brooded, except in its more northern range, the first brood developing on the leaves in May and June, the second brood on green grapes in July, and the third brood on ripening grapes in August and September. The early brood of this insect is so scanty that it is rarely noticed, and hence protective steps are seldom taken. Later in the season it multiplies with great rapidity, and particularly does it become numerous and destructive if grape gathering be deferred until a late period.

Remedies.—The use of poisons is not practicable except against the first brood, which develops on the green parts of the vine, and here the result is doubtful, because it is more than likely to breed on a great variety of foliage, and spraying would not afford much protection. Bagging the grapes as soon as the fruit sets will undoubtedly protect them from this insect, and at the same time from black rot. Of greater practical value, especially in larger vineyards, is the prompt collection and burning of all fallen leaves in autumn, thus destroying the hibernating larvæ and pupæ, and also the collection and destruction of diseased fruit wherever feasible. Early gathering and shipping or disposal of fruit otherwise is a particularly valuable step, as it insures the removal of the larvæ in the grapes from the vineyard if not their destruction in wine making. All fallen fruit should also be gathered and destroyed.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C.

[Only the bulletins named below are available for distribution.]

- No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. Pp. 8.
- No. 16. Leguminous Plants for Green Manuring and for Feeding. Pp. 24.
- No. 18. Forage Plants for the South. Pp. 30.
- No. 19. Important Insecticides: Directions for Their Preparation and Use. Pp. 20.
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- No. 55. The Dairy Herd: Its Formation and Management. Pp. 24.
- No. 56. Experiment Station Work—I. Pp. 30.
- No. 57. Butter Making on the Farm. Pp. 15.
- No. 58. The Soy Bean as a Forage Crop. Pp. 24.
- No. 59. Bee Keeping. Pp. 32.
- No. 60. Methods of Curing Tobacco. Pp. 16.
- No. 61. Asparagus Culture. Pp. 40.
- No. 62. Marketing Farm Produce. Pp. 28.
- No. 63. Care of Milk on the Farm. Pp. 40.
- No. 64. Ducks and Geese. Pp. 48.
- No. 65. Experiment Station Work—II. Pp. 32.
- No. 66. Meadows and Pastures. Pp. 24.
- No. 67. Forestry for Farmers. Pp. 48.
- No. 68. The Black Rot of the Cabbage. Pp. 22.
- No. 69. Experiment Station Work—III. (In press.)

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 80.

THE PEACH TWIG-BORER:

AN IMPORTANT ENEMY OF STONE FRUITS.

BY

C. L. MARLATT, M. S.,

First Assistant Entomologist.



WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1898.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., June 15, 1898.

SIR: I have the honor to transmit herewith a Farmers' Bulletin on the peach twig-borer, an important enemy of stone fruits. It has been prepared by my first assistant, Mr. C. L. Marlatt, and consists in the main of a revision of an article published in Bulletin No. 10, new series, of this Division. It is issued in its present form to supply a demand for a larger circulation of the information contained in the article cited, particularly in California and elsewhere on the Pacific slope, where the twig-borer is especially abundant and destructive.

Respectfully,

L. O. HOWARD, *Entomologist.*

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE PEACH TWIG-BORER.

(*Anarsia lineatella* Zell.)

INTRODUCTION.

This insect is of European origin, but has been known to occur in the United States since 1860. It has been very injurious at times to peach trees in the peach-growing sections of the East, notably in Maryland, Delaware, and Virginia, also in New Jersey and New York, and more recently in West Virginia. In California and Oregon, and elsewhere on the Pacific slope, its injuries have taken a wider range, including damage to the apricot, almond, nectarine, prune, pear, and perhaps other fruit trees in addition to the peach.

In California it is listed as one of the three or four worst insect pests occurring in the State. In Washington as many as one hundred larvæ, or instances of damage to as many twigs, have been counted on a single tree. In Oregon this insect is stated to be next to the peach-tree borer in the amount of damage it occasions, particularly in the Willamette Valley. In western Colorado it is very destructive to peach, plum, apricot, and almond.

The injury occasioned by this insect is limited almost exclusively to the work of the hibernating larvæ during the latter part of April and first of May, when they bore into the shoots of new leaves, killing the growing terminals and preventing the development of the branch, although sometimes a whorl of living leaves may remain at the base. Much of the new growth of the tree is often killed, in many instances the branches remaining with scarcely a bud or shoot which has not been thus destroyed. This necessarily results in greatly checking the vigor and fruiting capacity of the tree, and causes an irregular and knotty growth.

The summer broods of larvæ feed beneath the bark or in the fruit stems, occasionally, when nearly full grown, boring into the fruit; but such damage is not ordinarily noticed and is slight as compared with the injury occasioned by the first or hibernating brood of larvæ.

RECENT STUDIES OF THE INSECT.

Up to comparatively recent years the knowledge of this insect has been practically confined to its injury to peach twigs, either in terminals before the trees leaf out in the spring, a rare form of attack, or in the

young shoots—the usual and destructive habit—and later and more rarely in the ripening fruit. In connection with these descriptions of damage are also accounts of what was then believed to be the same insect affecting the strawberry, one brood wintering in the half-grown larval stage in the crown of the plant, and a second brood working during early summer in the young shoots and runners.

The confusion of these two distinct species, attacking widely dissimilar plants, continued until 1897, and still obtains to a great extent. There necessarily resulted a thorough misapprehension of the habits of the twig-borer and the suggestion of needless precautionary measures, such as the abandonment of the culture of the strawberry, at least in proximity to peach orchards.

In 1893 some very interesting observations were made by Mr. Ehrhorn, in Santa Clara County, Cal., and reported by Mr. Caw, demonstrating that the twig-borer winters, in the larval stage, not in the crown of the strawberry plant, as had been previously thought, but in peculiar chambers situated for the most part in the crotches of the branches of the trees attacked, the larvæ leaving these chambers in the spring to do the notable damage characteristic of the species.

While passing through California in the fall of 1896, the writer examined, in company with Mr. Ehrhorn, the curious hibernating chambers made by the newly-hatched larvæ, and the habits of this insect, as far as then known to Mr. Ehrhorn, and substantially as had been already recorded by Mr. Caw, were explained to him. The discovery of this peculiar hibernating habit of *Anarsia lineatella* is very interesting in itself, and is also a long step toward the completion of our knowledge of the life history of the insect, and is especially valuable as suggesting better means than any heretofore known of preventing damage from it.

Arrangements were made with Mr. Ehrhorn at the time to supply the Department with ample material of the young larvæ in their hibernating cells; and, throughout the winter, spring, and early summer of 1896-97, material was repeatedly sent for study to Washington, D. C.

Some of the twigs containing the young hibernating larvæ were during the winter fastened to peach trees growing in the entomological nursery attached to the insectary. Most of the larvæ in these twigs had been killed by a predaceous mite, and some few, perhaps, died as a consequence of the drying up of the twigs, but a considerable number of them wintered safely and ultimately entered the new shoots in the early spring and completed their development. With this material we were enabled to study their habits out of doors under natural conditions, following the species carefully through two generations and into the commencement of a third, as will be detailed below. By the end of August our working stock died out and we were unable to secure fresh supplies. The studies made in Washington were supplemented and confirmed by the field observation of Mr. Ehrhorn covering the same period and continuing until the hibernating cells reappeared in the crotches in August and September.

About the same time Mr. A. B. Cordley, entomologist of the Oregon Experiment Station, was also investigating the habits of this insect, his account comprising a description of the injury to peach and prune twigs in early summer, and the work of similar larvæ in strawberry beds in October, the latter larvæ wintering in the crowns of the plants.

HISTORY AND DISTRIBUTION.

The peach twig-borer is apparently an Old World species and probably a very ancient enemy of the peach, with little doubt coming with this fruit from western Asia. It was described in Europe in 1839, and in this country in 1860. The American species was afterwards shown to be identical with the European peach moth. As an important injurious insect in this country, attention was first drawn to it about 1872 by Mr. Glover, a former entomologist of the Department, and also by Mr. Saunders, of Ottawa, the report of Mr. Glover being the first published. Glover's report describes excessive damage by it as a twig-borer in young peach orchards in Maryland, and Saunders's report, while relating chiefly to marked injury by a crown-borer in strawberry beds (now known to be a different insect), refers also to injury to the peach twigs in Ontario. Some years later, Prof. J. H. Comstock, while entomologist of the Department, reported considerable damage from the peach twig-borer in Virginia and in the District of Columbia, and first noted the peculiar fruit inhabiting brood. Later the insect was made the subject of an article by Dr. J. A. Lintner, in which it is reported to have occasioned damage to peaches in several localities in the State of New York. We also have accounts by Prof. C. V. Riley, of injury to strawberry plants in Illinois, referred by him to *Anarsia lineatella*, and also articles on this insect, particularly as a strawberry miner, by Prof. S. A. Forbes. Very great damage to peaches in Kent and Sussex counties, Del., was reported later by Riley and Howard.

On the Pacific slope record was made of injury by it to various stone fruits by Mr. Coquillett, and later similar damage was reported from Vancouver. We have also the results of the investigations by Mr. Ehrenhorn in California, and the recently published accounts by Mr. Cordley relative to the insect as affecting peaches and prunes in Oregon, and also in strawberry beds—a similar but undoubtedly distinct insect.

That this twig-borer is very destructive to the peach, plum, apricot, and almond in western Colorado is shown by recent accounts, and damage from it has also been lately reported in West Virginia.

In addition to the more important published accounts, injury from the twig borer has been often recognized and reported by various observers in recent years. Nearly all these reports refer to the injury to twigs of stone fruits, and very few to the strawberry, the allied insect which infests the latter either being more rare or less often observed. The records of this Department show the presence of the twig-borer in at least twelve States, and give it a range which indicates that it is practi-

cally as wide-spread in this country as is the culture of its principal food plant.

If not already cosmopolitan in distribution, the peach twig-borer is rapidly becoming so, and will probably follow the peach and other stone fruits wherever they are cultivated, especially as its peculiar hibernating habit greatly facilitates its distribution with nursery stock.

LIFE HISTORY AND HABITS.

The fall brood of larvæ discovered by Mr. Ehrhorn may be taken as a convenient starting point in the life history of the peach twig-borer. In the fall, according to Mr. Ehrhorn, they appear as very small larvæ, living and working in the spongy bark chiefly at the crotches of the branches of the peach, and he surmises that they are from eggs deposited in these situations. Here the larvæ are supposed to grow

slowly until the new growth appears in the spring, when they leave their cells in the bark and enter the new shoots. It is stated, also, that frequently the larvæ are nearly full grown when they attack the young growth. A later brood is said to attack the fruit near the stems. The occurrence of the larvæ during the winter in the situations described is also thought to explain the fact frequently noted that the under and inside twigs, being the more accessible, suffer the most, while the exterior and topmost branches escape.

Later studies confirm, in the main,

Mr. Ehrhorn's conclusions as to

the habits of the larvæ. That the larvæ make any essential growth in the winter, however, is probably a wrong inference, as will be shown later, and the nearly full-grown larvæ referred to were doubtless individuals that were wandering from one point to another, and had merely reached nearly full growth before they were observed.

Both in the orchards of California and by means of the abundant material received at this office we have been enabled to make a careful study of the hibernating galleries, or chambers, of the young larvæ. These occur not only in the crotches of the smaller and sometimes quite large branches, but many of the larvæ utilize the roughened bark at any point. They burrow into the bark for a short distance, penetrating little more than the upper superficial layer, and form slightly elongated chambers (fig. 1, *c*), which are lined with white silk and the opening afterwards closed. The location of the larvæ may be readily recognized by the little masses of projecting excrement or comminuted bark at the entrances to the burrows (fig. 1, *a*, *b*). The size of the burrow and

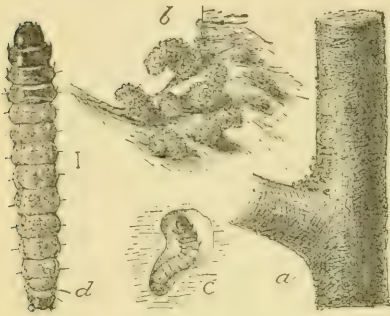


FIG. 1.—*Anarsia lineatella*: *a*, twig of peach, showing in crotch minute masses of chewed bark above larval chambers; *b*, latter much enlarged; *c*, a larval cell, with contained larva, much enlarged; *d*, dorsal view of young larva, more enlarged (original).

the fact of its being lined with silk precludes the idea that the larva feeds in the fall or during hibernation, except perhaps in the mere operation of excavating the chamber.

The young larva, as taken from the burrow, is not above 2 millimeters long, and is of a general yellow color, with the head and cervical and anal plates dark brown, almost black (fig. 1, *d*).

While in their winter quarters the larvæ are subject to the attacks of predaceous mites, and many of them are destroyed by this means, as will be later noted. They are also occasionally parasitized by a chalcidid fly.

Early in April the larvæ begin to abandon their hibernating quarters and attack the new leaf shoots, but some individuals were found in the crotches by Mr. Ehrhorn as late as April 21. The damage becomes noticeable, as a rule, at the time the shoots are from one-half inch to 2 inches in length, or, more properly speaking, mere clusters of newly expanded leaves.

Glover's account of their working downward in the old twigs from the terminal buds before the starting of the leaves in April apparently can not be questioned, but seems not to be the normal course, as shown by the observations since made.

In our experience, the larvæ begin to migrate only after the new foliage has begun to put out, and they attack the new shoots at any point, generally, however, from one-half inch to an inch from the apex, either near or in the crotch formed by the leaf petiole and the stem. The longest burrow observed was $1\frac{1}{2}$ inches and the shortest one-fourth inch. Sometimes the burrow extends about one-eighth inch above the entrance, and occasionally the larvæ simply eat into the shoot as far as the pith and then go elsewhere. The larvæ are seemingly restless and not easily satisfied, and are continually moving from one shoot to another, and are most active travelers. In this way a single larva may destroy or injure several shoots before reaching maturity, thus greatly increasing the damage.

Professor Comstock's observations on the habits of the larvæ in the young shoots are slightly at variance with the above. He says the larvæ puncture the shoots at the base, eating them off completely, the severed twigs remaining attached to the branch by the gummy substance which exudes from the wound. This particular form of injury we have not noted.



FIG. 2.—*Anarsia lineatella*: *a*, new shoot of peach withering from attack of larva; *b*, larva enlarged; *c*, pupa enlarged; *d*, tip of pupa more enlarged (original).

When working in the succulent new growth the larvæ bores rather rapidly, sufficiently so at least to excavate a burrow two-thirds of its length in an hour. The length of time spent by the hibernated larvæ in coming to full growth in the green shoots is comparatively short, not exceeding ten to fifteen days.

In California, and also in the District of Columbia, the larvæ begin transforming to pupæ in the latter part of April, and the moths of the first brood emerge throughout May. In Colorado, Mr. Gillette has bred the moths the first of June and also toward the end of July. In Oregon, Mr. Cordley secured his first pupa on May 8 and his first moth on May 17.

The adult larva tapers strongly toward either end, and attains a length of three eighths to a half an inch, or slightly more when in motion. It is of a dull reddish-brown color, the reddish color predominating before maturity and the latter after maturity, and the head and the cervical and anal shields are dark brown or almost black. The space between the segments is noticeably light-colored, and especially between the second and third thoracic segments. The hairs are long and spring singly from minute tubercles. Other details of structural features are shown in the illustration (fig. 2, *b*).

In confinement the larva on reaching full growth spins a scanty web, in no sense a close cocoon, in the leaves and rubbish about the trees, or on the trees in the dried and shriveled leaves of the injured shoots, or it attaches itself exposed on the twigs or bark. After thus securing itself the larva immediately pupates, becoming a brown, rather robust, chrysalis (fig. 2, *c, d*). In midsummer these transformations are very quickly accomplished. A larva, for example, which webbed up June 29, pupated July 1, and the adult emerged July 8.

Mr. Ehrhorn states that it is very difficult to find the pupæ in orchards, as the larvæ hide in all sorts of places, as in crotches of the branches, between dried leaves, and about small peaches likely to drop off.

The chrysalis stage lasts from seven to ten days, and the moths of the first brood begin to appear early in May and continue to emerge throughout this month and into June in the latitude of Washington.

The adult moth is less than a quarter of an inch in length, expanding a little more than half an inch, and is of a beautiful dark-gray color, with darker spots on the forewings, as indicated in the illustration (fig. 3). It is a handsome insect, and has a peculiar way of resting with its palpi bent back over its head and its antennæ laid closely down on the wings.

The actions of the moths out of doors have been recently described by Mr. Cordley. During the daytime they remain perfectly still on the bark of the tree, and with the forepart of the body slightly raised and the labial palpi held rigidly upright in front of the face. They so closely resemble small, rough projections of the bark that it is almost impossible to distinguish them. When disturbed they dart rapidly about for an instant and then as suddenly alight in a new position.

The egg-laying habits of this insect previous to 1897 having been merely a matter of conjecture, special effort was made to get the facts concerning this feature of the life history. A number of moths reared in the insectary were confined about May 10 with peach twigs 8 to 10 inches in length, of this year's growth. The examination of the material was unfortunately too long delayed, but on May 28 it was found that many eggs had been deposited on these peach twigs, an egg having been placed apparently just above the base of the petiole of nearly every leaf. When examined, most of the eggs had hatched and the larvæ had entered the twigs at or near the crotch formed by the leaf and twig, the point of entrance being indicated by a little mass of brown excrement.

The egg had evidently been placed in the protection formed by the two little spurs at the base of the petiole. Subsequently many other eggs were obtained from other moths, and they were, for the most part, similarly situated, namely, around the base of the leaves. In one instance nine eggs were deposited around the base of a single leaf, six of them close together under one of the bracts at the base of the petiole and three in the depression or scar left by the second bract, which had dropped.

The recently deposited eggs are white in color and iridescent, but before hatching become distinctly orange. They measure about four-tenths of a millimeter in length by two-tenths of a millimeter in breadth, are somewhat ovoid, and are lightly attached lengthwise to the twig by a glue-like material. Under a high power they are seen to be coarsely and rather regularly reticulated, as shown in the illustration (fig. 4, *a*).

In confinement the moths live about ten days, and most of the egg-laying is in the first half of this period. The habits above described are those of caged moths, but it is reasonable to suppose that in a state of nature the eggs are deposited in much the same way, and this is rendered almost cer-

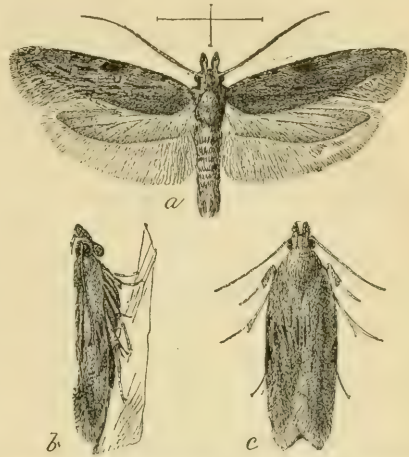


FIG. 3.—*Anarsia lineatella*: *a*, moth with spread wings; *b* and *c*, same with wings closed, illustrating position normally assumed—all much enlarged (original).

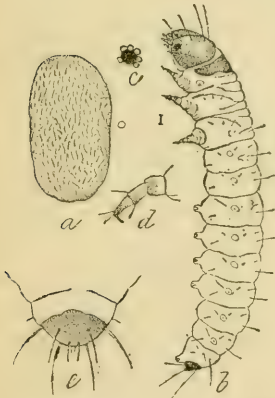


FIG. 4.—*Anarsia lineatella*: *a*, egg; *b*, young larva; *c*, eye; *d*, thoracic leg of larva; *e*, anal segment from above—all greatly enlarged (original).

tain by the great regularity noted in the manner of their deposition. In but one or two instances were the eggs placed in other situations—one being placed on the upper surface of a leaf close to the midrib, and two together placed in a groove at the side of the base of the leaf.

From eggs deposited later than those first mentioned, viz, about June 3, larvæ appeared June 15, indicating a period of about twelve days between the laying of the egg and its hatching.

The newly hatched larvæ measure about 1 millimeter in length and are of a very pale yellow color, with the head and cervical and anal plates black and the thoracic legs dusky. When first noted they had excavated channels somewhat longer than themselves and about twice as broad into the twigs, the entrance being marked by a small mass of excrement. By June 3 most of the older larvæ had abandoned their original burrows and were constructing new ones in similar situations on fresh branches of the peach, with which they were from time to time supplied. This they continued to do, viz, to construct new burrows every few days until they were full grown. On June 23, of the three remaining individuals of this lot of larvæ, one had already pupated in a folded leaf and the other two were fully grown and about ready to transform, which they both did before the end of the month.

About the end of June some peaches were received from Mr. Ehrhorn, said to be infested with the second brood of larvæ. Some of the peaches had been bored into a little way near the stem by what was evidently, from the size and nature of the burrows, nearly full-grown larvæ of the second brood. One of these was found, and also one pupa. On further examination, however, it was discovered that the larvæ of what is undoubtedly the third brood (the second of the summer broods) were present in numbers, not in the fruit, but in the short stems of the fruit, which at this season are green and somewhat succulent. In these stems they had made their little chambers not unlike those in the twigs above described or those in the crotches in the fall, except that they were for feeding purposes and not lined with silk, as are the latter. Others were also found at the base of the leaf stalks, just as we had been finding them in our breeding cages.

We were unable to carry our breeding-cage material farther than this point at Washington, D. C., and Mr. Ehrhorn was unable to furnish additional supplies, but he writes that he found the minute larvæ in the crotches of the trees as early as August 21. It would seem from this last and very important observation that some, at least, of the fourth brood of larvæ, if not all of them, go into winter quarters, and at a period much earlier than would have been supposed.

These facts go a long way toward clearing up the life history of this insect, and indicate a much more uniform habit in the different broods than has hitherto been supposed.

The old idea that this insect is double-brooded, the first brood living in the twigs and the second brood affecting the ripening fruit, must be

abandoned. At the time of the appearance of the first brood of moths during the month of May the fruit of the peach is of considerable size, especially by the end of the month, but is green, hard, and densely hairy, and is probably rarely if ever chosen by the parent moths as a nidus for her eggs. The normal location of the eggs and the point at which larval development begins is indicated by the foregoing notes, and there is no reason to doubt but that at all seasons of the year larvæ develop in the new growth, entering normally at the axils of the leaves or in the stems of the green fruit. In these situations the eggs are placed and the young larvæ construct their little oval chambers, which they abandon from time to time to make new ones, rarely doing enough damage in the later broods at any one point to be noticeable. As they attain larger size they travel more and often bore into fruit near the stem, where the greater exudation of gum and more serious character of the injury draw attention to them. In the case of the burrows in the twigs the more abundant new growth and more mature condition of the wood render the injury much less noticeable, nor are the results of the attacks so marked as in the injury to the new growth in April.

Our records for the first summer brood indicate a period of about six weeks as necessary for its complete development. The time necessary in the warmer months for the later broods is probably even less, and it is evident that there are certainly three broods of larvæ annually, if not four.

One of the important points remaining to be cleared up in regard to this insect is whether the larvæ found in the crotches of the branches in late summer and fall come from eggs placed in these situations or are migrants from some other parts of the plant. Mr. Ehrhorn's supposition that the eggs were placed by the moth where the larval chambers are afterwards found is borne out by the small size of the larvæ, which are not much larger than when newly hatched. The comparatively large size of the egg, and its striking appearance, and the lack of any attempt at concealment of it should enable one, where the insect is abundant, to clear up this uncertain feature without difficulty.

THE STRAWBERRY CROWN-MINER A DISTINCT INSECT.

The generally held belief hitherto that the lepidopterous crown-miner of the strawberry is the same insect as the twig-borer of the peach will have to be abandoned. If there were no other evidence on which to base this conclusion, the habits of the twig-borer, as now known, throughout the year are so peculiar and distinctive as to render very improbable the supposed strawberry infesting habit.

That we have two distinct insects is also convincingly shown by a comparative study of the larvæ from the strawberry and from the twigs of stone fruits, obtained from various parts of the country, made in connection with an examination of the published descriptions of larvæ and their habits from both sources. So dissimilar are the larvæ

that there is no basis whatever for connecting them with the same insect, and in fact they probably belong to different families.

The moths of the strawberry crown-miner, on the other hand, are very similar in appearance to the moths of the twig-borer, as dry, mounted objects. The habits of the living insects, however, of the two species are, on the authority of Mr. Cordley, very dissimilar. The twig-borer moths are slightly larger and darker colored than the strawberry insect, and invariably take an elevated position in the breeding cage with the fore part of the body slightly raised and the labial palpi held rigidly upright in front of the face, as elsewhere noted. The moths reared from the strawberry crowns, on the other hand, crawl down among the vines, even into crevices in the soil, apparently for the purpose of depositing eggs upon the crowns of the plants, and when disturbed run or flutter about with wings half spread.

This strawberry insect seems undescribed although its larval habits are fairly well known. The important consideration, at any rate, is established that the culture of the strawberry presents no menace to the grower of stone fruits, since the damage under discussion to the two plants has no connection.

NATURAL PARASITES.

That the larvæ of the peach twig-borer are attacked by parasites during the hibernating period has already been alluded to, and in fact, of the material received from Mr. Ehrhorn, nearly all had been destroyed by a minute predaceous mite, *Pediculoides ventricosus* (fig. 5). In most instances nothing remained of the larvæ except the empty heads.

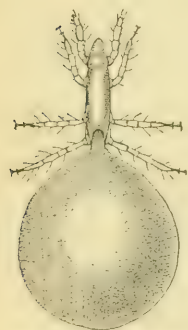


FIG. 5. — *Pediculoides ventricosus* — much enlarged (original).

Two minute hymenoptera, or four-winged fly parasites, have also been reared from the larvæ. The first of these was obtained by Professor Comstock, who in his studies of the peach twig-borer reared a parasite from it which he did not name, but which was later described by Dr. L. O. Howard as *Copidosoma variegatum*. The second fly parasite of *Anarsia* was obtained from the material in tree crotches submitted by Mr. Ehrhorn, and proves to be *Orymorpha livida* Ashmead, a wide-spread species quite variable in point of size.

Of these parasites, in California the greatest benefit is derived from the mite, which, as we have already stated, frequently causes the death of from 75 to 95 per cent of the young larvæ.

REMEDIES AND PREVENTIVES.

The common method of procedure against this insect, and the one hitherto generally suggested, is to clip off and burn the withering infested tips in the spring as soon as the injury is noted. The forego-

ing life history emphasizes the fact that it is necessary to do this very promptly, for the larvæ remain in these situations a very short time, and early in May will have abandoned their burrows in the young shoots to transform, often elsewhere, although sometimes pupating in the withered leaves. The presence of dying terminals does not always indicate that a larva is necessarily present, since in many instances it will have wandered to some other point. With large orchards this step would be a very tedious one, and with trees of any size often impracticable.

WINTER TREATMENT WITH KEROSENE EMULSION.

The knowledge of the hibernating habits of this insect indicates a more effective method of control. This consists in spraying the trees during December or January, or any time after the foliage has fallen, with kerosene emulsion, resin wash, or some similar oily preparation which will penetrate the burrows and destroy the young larvæ. Mr. Ehrhorn found the kerosene treatment very satisfactory, as practiced in California in the winter of 1897-98, the little excremental pellets of the larvæ absorbing the oily mixture and leading it directly to the insect in its hibernating cell. For California Mr. Ehrhorn recommends that the application of the mixture should be begun in December.

Kerosene emulsion has one advantage over other oily preparations, such as the resin wash, in that it is more penetrating and will be more certain of reaching the larvæ.

Where the emulsion is to be prepared by hand it is better to make it in rather small quantities at a time in order to secure a perfect combination of oil and soap. The proportions usually taken are as follows: Kerosene, 2 gallons; whale-oil soap, half a pound; water, 1 gallon.

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct discharge nozzle, throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, the emulsion will keep indefinitely, and should be diluted only as wanted for use.

For the treatment of large orchards, requiring large quantities of the emulsion, it may be advisable to prepare it with the aid of a steam or gasoline engine and suitable large tanks, as has been very successfully and economically done in several instances, all the work of heating, churning, etc., being accomplished by this means. When thus made the following proportions may be suggested: Kerosene, 10 gallons; whale-oil soap, 2½ pounds; water, 5 gallons. As a winter wash the emulsion may be diluted with about six volumes of water, making for

the larger quantity about 100 gallons and the smaller about 20 gallons of spraying mixture.

When hard water is employed in the making of the emulsion or in diluting afterwards, it is necessary to use about 25 per cent more soap, or preferably the water may be broken with lye, or rain water may be used.

In the use of kerosene or other oily washes on plants, the application should be merely sufficient to wet the plant without causing the liquid to run down the trunk and collect about the crown; usually at this situation there is a cavity caused by the swaying of the plant in the wind, and the accumulation of the insecticide at this point may result in the death or injury of the plant. It is even advisable to mound up the trees before spraying or to see that the earth is firmly packed about the base. Care should also be taken in refilling the tank to see that no free oil is allowed to accumulate in the residue left at the bottom.

In line with the use of kerosene emulsion may be suggested the use of pure kerosene mechanically combined with water in the act of spraying, as is now effected by a style of pump specially made for the purpose. A 20 to 25 per cent solution of the kerosene can be used without danger to the plant in its dormant condition, but it is necessary to watch the apparatus employed for this work very carefully to see that the proportion of oil to the water does not change, and on the whole it is much safer and more satisfactory to use the kerosene emulsion, the strength of which may be known definitely in advance and is not subject to variation.

SPRING OR FALL TREATMENT WITH ARSENICALS.

The possibility of destroying the larvæ of the peach twig-borer by spraying the plants with arsenicals, either in the fall or spring, has also been suggested, but such treatment demands the greatest caution on account of the extreme sensitiveness of the foliage of the trees ordinarily attacked by this insect to scalding when sprayed with these poisons.

The fall treatment is directed against the last brood of larvæ, and to be effective the poison should reach the parts of the plant where the eggs are most apt to be placed, presumably the crotches of the branches. Many of the larvæ might thus be poisoned while eating through the bark preliminary to the construction of their winter retreats. To effect anything of value by this course the poison must be applied early—that is, before the eggs are deposited—and the feasibility of the treatment will depend somewhat on the condition of the trees and the damage that might result from scalding of the foliage in late summer.

As a spring treatment, the arsenical spray should be applied to the trees at the moment the leaf-buds begin unfolding, so that the first meal taken by the over-wintered larvæ will be a poisonous one. The difficulty

with this method is that already given—namely, the extreme sensitive-ness of the foliage of the peach and allied fruits to damage by scalding with arsenical sprays—and if this method is followed the poison should not be used in much greater amount than 1 pound of the arsenical to 400 gallons of water, previously mixing the poison up with an equal weight of lime in a small amount of water.

The experience in California with the arsenicals, as reported by Mr. Ehrhorn, has not been satisfactory. It has been found very difficult in actual practice to use them without danger to the plants. The winter treatment with kerosene emulsion, first described, is therefore especially and strongly advised.

FARMERS' BULLETINS.

Copies will be sent to any address on application to any Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C.

No. 22. The Feeding of Farm Animals. No. 24. Hog Cholera and Swine Plague. No. 25. Peanuts: Culture and Uses. No. 27. Flax for Seed and Fiber. No. 28. Weeds: And How to Kill Them. No. 29. Souring and Other Changes in Milk. No. 30. Grape Diseases on the Pacific Coast. No. 32. Silos and Silage. No. 33. Peach Growing for Market. No. 34. Meats: Composition and Cooking. No. 35. Potato Culture. No. 36. Cotton Seed and Its Products. No. 37. Kafir Corn: Culture and Uses. No. 39. Onion Culture. No. 41. Fowls: Care and Feeding. No. 42. Facts About Milk. No. 43. Sewage Disposal on the Farm. No. 44. Commercial Fertilizers. No. 46. Irrigation in Humid Climates. No. 47. Insects Affecting the Cotton Plant. No. 48. The Manuring of Cotton. No. 49. Sheep Feeding. No. 51. Standard Varieties of Chickens. No. 52. The Sugar Beet. No. 54. Some Common Birds. No. 55. The Dairy Herd. No. 56. Experiment Station Work—I. No. 58. The Soy Bean as a Forage Crop. No. 59. Bee Keeping. No. 60. 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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 99.

THREE INSECT ENEMIES OF SHADE TREES.

BY

L. O. HOWARD,
ENTOMOLOGIST.

[Reprinted, with some annotations by the author, from the Yearbook
of the Department of Agriculture for 1895.]



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., May 26, 1899.

SIR: I have the honor to transmit herewith a copy of an article contributed by me to the Yearbook for 1895, entitled "The shade-tree insect problem in the Eastern United States." I have found the reprints of this article of great use in correspondence, and as the edition is exhausted, I recommend that it be republished, under the title Three Insect Enemies of Shade Trees, as a Farmers' Bulletin. I have in preparation a more extended bulletin on the subject of shade-tree insects, but in the interval which will elapse before it is completed the Farmers' Bulletin reprint of the Yearbook article will be of service.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THREE INSECT ENEMIES OF SHADE TREES.

The space at command will not admit of a full treatment of the problem outlined in the [original] title of this article, and the writer has therefore brought together at this time some account of three species which are perhaps the most destructive among shade-tree insects, or which, at all events, have attracted the greatest attention during the past season. To this he has added a brief consideration of the relative immunity of shade trees from insect attack, and some remarks on the subject of general work against shade-tree insects in cities and towns.

One of the most striking features of the summer of 1895 has been the great abundance in many Eastern cities of several species of insects

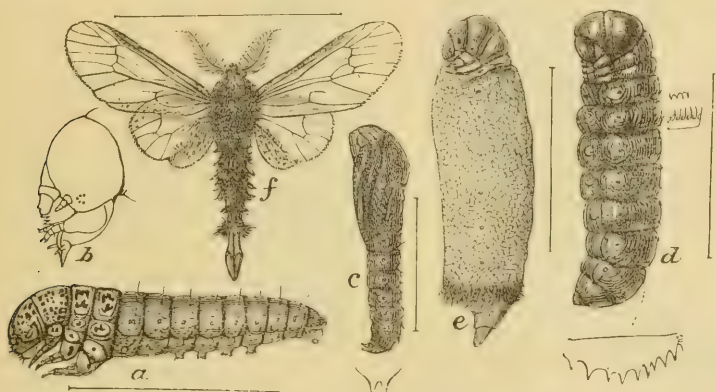


FIG. 1.—Bagworm (*Thyridopteryx ephemeraformis*). a, larva; b, head of same; c, male pupa; d, female pupa; e, adult female; f, adult male—all enlarged (original).

which attack shade trees. In almost every low-lying town from Charlotte, N. C., north to Albany, N. Y., the elm leaf-beetle has defoliated the English elms and, in many cases, the American elms. In certain directions this insect has also extended its northern range, notably up the Connecticut River Valley. The authorities in a number of Eastern cities have taken the alarm, and active remedial work will be instituted during the coming season. In cities south of New York the bagworm has been gradually increasing for a number of years until it has become a serious enemy to shade and ornamental trees for almost the first time since 1879 or 1880 (figs. 1 and 2). The white-marked tussock moth, the caterpillar of which has been for many years the most serious of the shade-tree pests in Philadelphia, New York, Brooklyn, and Boston, in 1895, for the first time within the recollection of the writer,

appeared in such numbers as to become of great importance in more southern cities, as Baltimore and Washington. The fall webworm (figs. 9, 10, and 11) was more abundant in Washington and the surrounding country than it has been since the summer of 1886.

These four insects are the principal shade-tree defoliators in the Eastern States, if we except the imported gypsy moth, which is at present fortunately confined to the immediate vicinity of Boston, and is being cared for by a thoroughly capable State commission. While the summer of 1895 may with justice be called an exceptional one as regards the great increase of numbers, yet these insects are always present and do a certain amount of damage each season, and, when an exceptional season comes, as it did in 1895, city authorities seldom find

themselves prepared to engage in an intelligent and comprehensive fight.

In cities farther west other leaf-feeders take the place of those just mentioned. The principal ones are, perhaps, the oak Edema, the cottonwood leaf-beetle, and the green-striped maple worm.

Several scale insects or bark lice are occasionally serious enemies to shade trees. Maples suffer especially from their attacks. The cottony

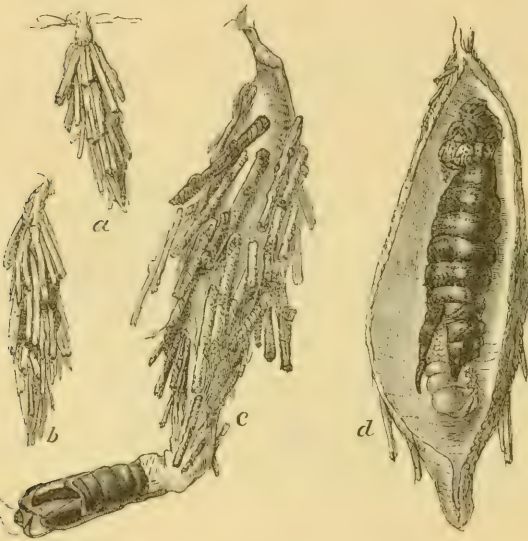


FIG. 2.—Bagworm at (a, b, c) successive stages of growth. c, male bag; d, female bag—natural size (original).

maple scale is found everywhere on all varieties of maple, and occasionally in excessive abundance. The cottony maple leaf scale, a species imported from Europe, is rapidly gaining in importance, and in several New England towns it has, during the past season, seriously reduced the vitality of many trees. The so-called "gloomy scale" has long been on the increase in Washington, D. C., and every year it kills large branches and even entire trees of the silver maples, which are so extensively grown along the streets of that city.

Certain borers are also occasionally destructive to many shade trees, and, in fact, in the northern tier of States these are the most important of the shade-tree enemies, the principal leaf feeders being either absent or becoming single brooded. Where absent their places are taken by less destructive species.

In fact, it is safe to say that shade trees suffer especially from insect attack throughout the region of country which is contained in the Upper Austral life zone.¹

Concerning the borers, it may be briefly said that these insects rarely attack vigorous and healthy trees, but should a shade tree lose its health through the attacks of scale insects, through rapid defoliation by leaf feeders, or through a leaky gas main or sewer pipe, different species of borers will at once attack and destroy it. There is one particular exception to this rule, and that is the European leopard moth, a most destructive species, which is at present of very limited range and confined to the immediate vicinity of New York City. No certain information is at hand which indicates that it has spread for more than 50 miles from the center of introduction. This insect attacks healthy trees, boring into the trunks of the younger ones and into the branches and smaller limbs of many shade and fruit trees. It is an extremely difficult species to fight, and it is fortunate that its spread is not more rapid.

THE IMPORTED ELM LEAF-BEETLE.

(*Galerucella luteola* Müll.)

Original home and present distribution.—The imported elm leaf-beetle (fig. 3) is a native of southern Europe and the Mediterranean islands. It is abundant and destructive in the southern parts of France and Germany, and in Italy and Austria. This beetle is found, though rarely, in England, Sweden, and north Germany, and gradually becomes less numerous and destructive toward the north. In middle Germany it is common, though not especially destructive. As early as 1837 it was imported into the United States at Baltimore, and is now found as far south as Charlotte, N. C. From this point it ranges northward in the Atlantic cities as far as Providence, R. I. Inland it has not passed the barrier of the Appalachian chain of mountains, and is practically confined to the Upper Austral region, as indicated in the map on page 210 of the Yearbook for 1894. Thus, up the Hudson River it has spread to Albany, N. Y., but on either side of the river, as the land rises into the foothills, it has stopped. In the same way it has more recently spread up the Connecticut River Valley to a point north of the New Hampshire State line, and also, to a less extent, up the Housatonic Valley. From our present knowledge it seems likely that its future spread as an especially destructive species will be limited by the northern border of the Upper Austral region, and that (as may happen at any time) should it once be carried by railway train across the southern extension of the Transition life zone, caused by the Alleghany and Blue Ridge mountains, it will spread unchecked

¹ Briefly defined by Dr. Merriam in his summary article on "The geographic distribution of animals and plants in North America," in the Yearbook of this Department for 1894, page 203.

through Ohio, Indiana, Kentucky, Tennessee, and other Western States.¹

Food plants.—No food plants other than elms are known. The common English elm (*Ulmus campestris*) is its favorite food, and the gardener's variety, the so-called Camperdown, or weeping elm, is attacked with equal avidity. The American, or white, elm (*U. americana*) ranks next among the favored species, with *U. montana*, *U. suberosa*, *U. flava*, *U. racemosa*, and *U. alata* in about the order named. No variety seems absolutely exempt. In the presence of *U. campestris* other elms are seldom seriously injured. Where *campestris* is absent, or where a single tree of *campestris* is surrounded by many American elms, the latter become seriously attacked.²

Life history and habits.—The elm leaf-beetle passes the winter in the adult, or beetle, condition in cracks in fences or telegraph poles, under the loose bark of trees, inside window blinds in unoccupied houses, in barns, and, in fact, wherever it can secure shelter. As soon as the buds of the trees begin to swell in the spring, the beetles issue from their winter quarters and mate, and as soon as the buds burst they begin to feed upon the leaflets.

This feeding is continued by the beetles until the leaves are fairly well grown, and during the latter part of this feeding period the females are engaged in laying their eggs. The eggs (fig. 3, *c*) are placed on the lower sides of the leaves, in vertical clusters of 5 to 20 or more, arranged in two or three irregular rows. They are elongate oval in shape, tapering to a rather obtuse point, orange yellow in color, and the surface is covered with beautiful hexagonal reticulations. These reticulations, however, can be seen only with a high magnifying power.

The egg state lasts about a week. The larvæ (fig. 3, *d*) as soon as hatched feed on the under surface of the leaf, gradually skeletonizing it. They reach full growth in from fifteen to twenty days, and then either crawl down the trunk of the tree to the surface of the ground or drop from the extremities of overhanging branches. At the surface of the ground they transform to naked, light orange-colored pupæ (fig. 3, *g*), a little over a quarter of an inch in length, and in this stage they remain for from six to ten days, at the expiration of that time transforming to beetles. The pupæ will frequently be found collected in masses at the surface of the ground in this way. On very large trees with shaggy bark many larvæ will transform to pupæ under the bark scales, or on trees of the largest size they may descend the main

¹ Since this was written the writer has learned that this passage of the Blue Ridge barrier has actually taken place during the past season. Mr. A. D. Hopkins, of the West Virginia Agricultural Experiment Station, has found that this insect has established itself at Elmgrove, in Ohio County, and at Wellsburg, in Brooke County, W. Va.

² The beetles rarely oviposit upon *Zeleora carpiniaefolia* and *Z. acuminata* on the Department grounds at Washington.

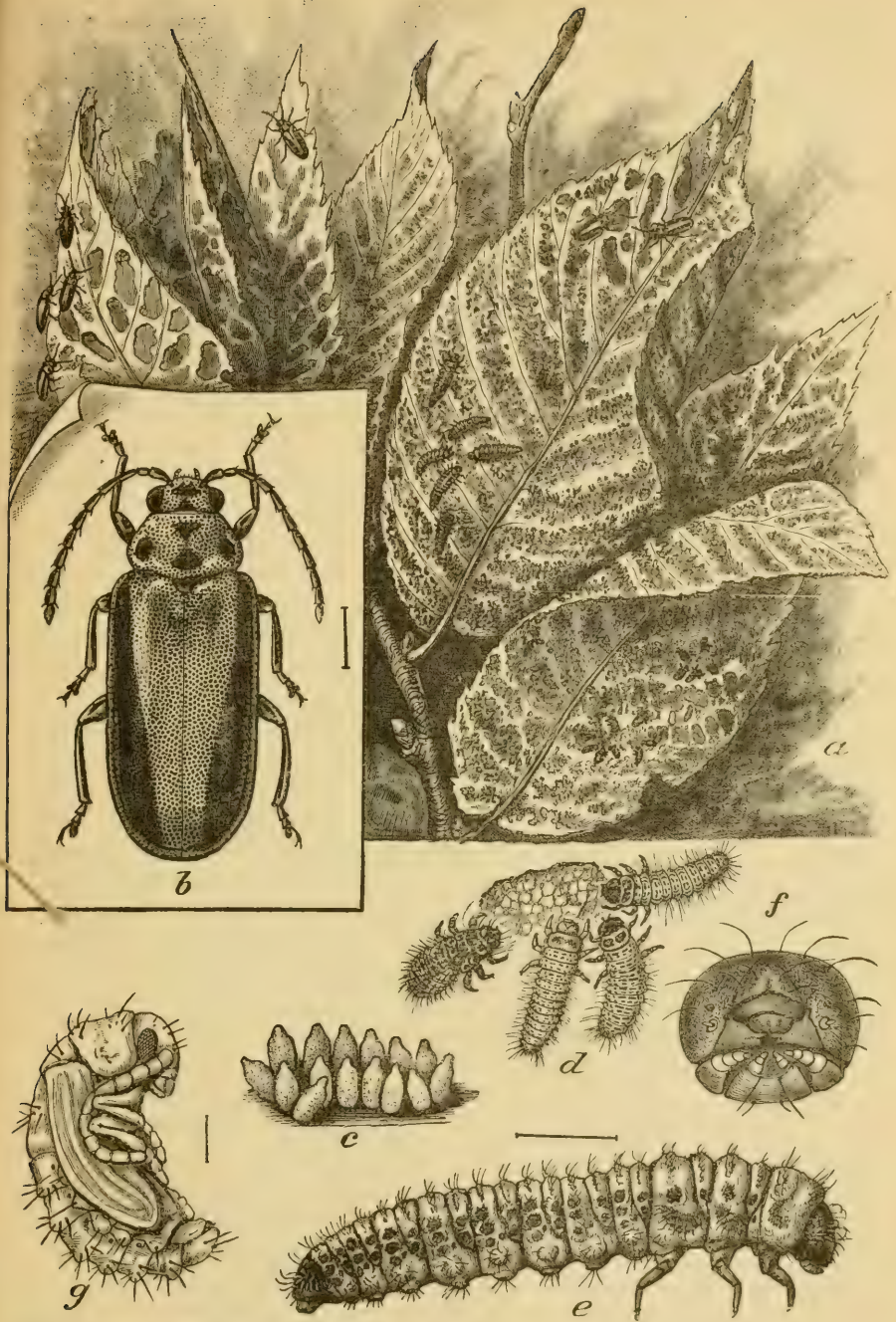


FIG. 3.—The imported elm leaf beetle (*Galerucella luteola*). *a*, foliage of European elm showing method of work of beetle and larva—natural size; *b*, adult beetle; *c*, egg mass; *d*, young larvae; *e*, full-grown larva; *g*, pupa—all greatly enlarged; *f*, mouth parts of full-grown larva—still more enlarged (original).

branches to the crotch and transform unprotected in the hollow of the crotch.

The larva is elongate, reaching when full grown (fig. 3, *c*) half an inch in length. When first hatched it is nearly black; as it increases in size it becomes, with each shedding of the skin, more distinctly marked with yellow, and when mature the yellow predominates, occurring as a broad dorsal stripe and two lateral stripes.

The difference between the early work of the beetles and the later work of the larvæ is recognized at a glance. The beetles eat entirely through the leaves and make complete, irregular holes, while the larvæ simply eat the parenchyma from below, skeletonizing the leaf.

The time occupied in egg laying is long, and it thus happens that at the time when full-grown larvæ, and even pupæ, are to be found there are also upon the leaves freshly laid eggs.

In Washington there are invariably two generations annually, the beetles developed from the eggs laid by the overwintered beetles themselves laying their eggs in July. The adults issuing from these eggs make their appearance in August. Farther north, at New Brunswick, N. J., and in the Connecticut cities, it may be said that there is normally a complete first generation and an incomplete second generation.

The proper food of the larvæ is the rather young and tender leaves. If the work of the first generation has not been complete, and the trees have not been so nearly defoliated as to necessitate the sending out of fresh leaves, or if a period of drought ensues after defoliation and prevents the putting out of a second crop of leaves, the beetles of the first generation do not lay eggs, but after flying about for a time seek winter quarters. This may occur as early as the middle of July. Where, however, defoliation has been complete and has been followed by a period of sufficient moisture to enable a tree to put out a fresh crop of leaves, the beetles of the first generation will lay their eggs and a second generation of larvæ will develop upon this comparatively tender foliage. Where similar conditions prevail in Washington and its vicinity, a third generation of larvæ may develop, though small in numbers, but the writer is convinced that even in Washington late-developing beetles of the first generation may hibernate.

Remedies.—The only thoroughly satisfactory safeguard against this insect consists in spraying the trees with an arsenical solution. The only other remedy which is worthy of mention is the destruction of the larvæ at the surface of the ground before or after they transform to pupæ. The latter remedy, however, is not complete, and even where it is carefully carried out for every tree in a city it will do no more than reduce the numbers of the insects by perhaps two-thirds.

Ten years ago a proposal to spray the enormous elms which are to be found in many Northern towns would have been received with ridicule, but of recent years the practicability of the plan has so frequently been demonstrated that there is no hesitancy in commending

it to more general city use. Probably the largest elm tree in America, the Dexter elm at Medford, Mass., has been successfully and economically sprayed by the Gypsy Moth Commission. It is necessary to have especial apparatus constructed, and it is equally necessary to have the work done by men who are accustomed to it or at least are good climbers. The first successful work of this kind was probably that done by Prof. John B. Smith, on the campus of Rutgers College. He had a strong barrel pump, and carried the nozzle at the end of a long rubber tube, with a bamboo extension pole, up into the center of the trees by climbing a ladder to the main crotch. From this point the spray was thrown in all directions, and the tree was thoroughly coated with the mixture in a minimum of time.

The Gypsy Moth Commission, in their earlier spraying work, sent their large tank carts through the streets, stopping at each tree and sending one or more men with hose and extension poles into it, thus covering hundreds of large trees in a single day. If steam sprayers are used (and the town or city fire engines can be and have been used to excellent advantage in this way), the necessity for climbing the trees may be largely avoided. By means of multiple-discharge hose both sides of a tree, or even of two trees, may be sprayed at once, and the extent of territory that may be covered in a day is surprising. The elm trees in a small park may be treated economically and without much difficulty by two or three men with a handcart tank. This method has been adopted on the large grounds of the Department of Agriculture with absolute success.

The writer's experience at Washington leads to the conclusion that it is important to spray trees once just after the buds have burst. This spraying is directed against the overwintered beetles. If a large proportion of these beetles can be destroyed by poisoning the leaves which they eat, not only will a great deal of leaf perforation by the beetles themselves be prevented, but the number of eggs laid will be very greatly lessened. A second spraying should be conducted two weeks later. This is directed against the larvæ, the majority of which will perhaps have hatched by that time or soon after. A third spraying, and even a fourth, or under exceptional circumstances a fifth, may be required if it is considered necessary to keep the trees fresh and green, and particularly if the earlier sprayings have been followed by rains, as is apt to be the case in the earlier part of the season. In Bridgeport, Conn., where only a part of the trees are sprayed and these by private enterprise, an even greater number of operations have been found desirable. Three thorough sprayings of all the trees in a given precinct will probably be as much as will be required, especially if this be done year after year and some pains be taken to destroy such of the larvæ as may successfully develop and descend for transformation. Even two sprayings, covering all the elms of a city or town, will be well worth the expense.

The substance to be used in these spraying operations may be Paris green, London purple, or arsenate of lead. The directions for the use of these substances have been so often repeated, that it is not worth while to mention them here.

The other remedy—the destruction of the descending larvæ and the quiescent pupæ—is, as above stated, and must always be, incomplete. The standard kerosene emulsion, diluted one part to five parts of water, will destroy the insects in either of these stages. This has been successfully used in several New England towns the past season, particularly in New Haven. It must be applied to the base of the trunk and under the entire limb spread of the tree. The rough bark must be removed to a slight extent (the writer does not advocate severe scraping), leaving as few crevices as possible which may harbor the pupating insects. If a tree is very large, it will pay occasionally to climb into the main crotch and destroy such individuals as may have collected at that point. Experience leads us to the estimate that on large trees not more than one-half to two-thirds of the larvæ reach the base of the trunk and transform at that point. The extent to which larvæ drop from overhanging branches has been questioned, and it is sometimes a difficult matter to decide. The city forester of Springfield, Mass., however, called our attention to a peculiar and eminently satisfactory case where the drooping branches of a large elm extended completely over a house on the other side of which there were no elm trees. On the far side of the house, beneath the tips of the overhanging branches, the larvæ and pupæ were collected in large numbers in the summer of 1895.

THE WHITE-MARKED TUSSOCK MOTH.

(*Orgyia leucostigma* Smith and Abbot.)

Original home and present distribution.—This insect is a native of North America. It ranges from Jacksonville, Fla., to Nova Scotia, on the eastern coast, and extends west certainly as far as Keokuk, Iowa, and probably farther, although the records at command include no actual captures beyond this point.¹ It does not occur in California, so far as learned.

Food plants.—It attacks almost every variety of shade, fruit, and ornamental trees, with the exception of the conifers. In the city of Washington it seems to select by preference the poplars, soft maples, the elms, alders, and birches, as well as the willows. It is also found here on apple, pear, cherry, plum, peach, other varieties of maple, locust, box elder, ash, catalpa, rose, horse-chestnut, persimmon, sycamore, mulberry, and a number of other trees.

Life history and habits.—This insect passes the winter in the egg state. The overwintering eggs are laid by the female moth in the latter

¹ Prof. L. Bruner has since reported this species from Omaha and Lincoln, Nebr.

part of September, in a glistening white, frothy-looking mass attached to the outside of the cocoon. They are seen at a glance, owing to their pure white color, and remain conspicuous upon the trees until spring. The caterpillars hatch in Washington in April and May. They are represented at different stages of growth in figs. 4, 5, and 6, and in view of the care with which these figures have been drawn detailed descriptions will be unnecessary. They cast the skin five times, exhibiting a different character after each molt, as indicated in the

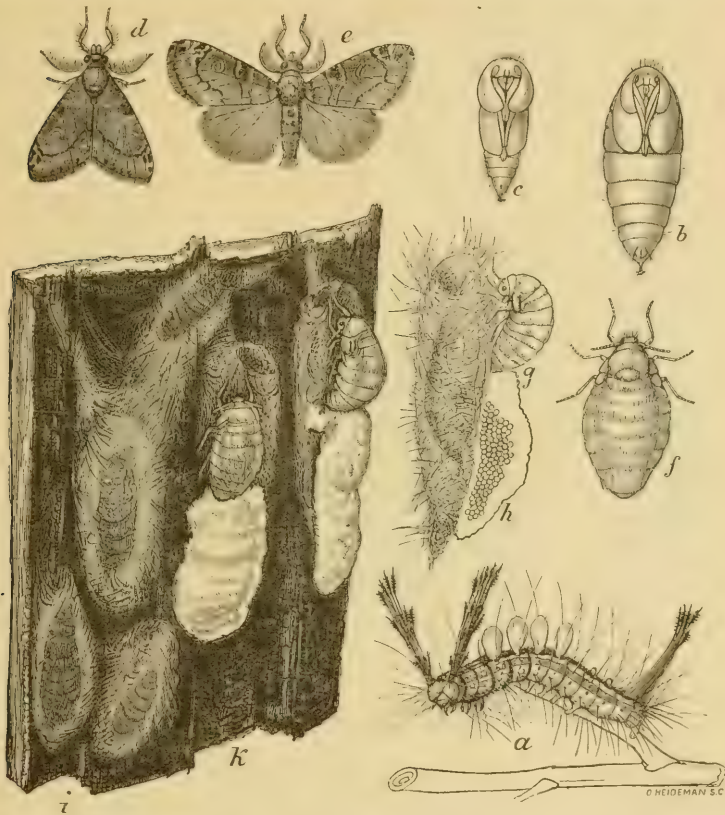


FIG. 4.—*Orgyia leucostigma*. *a*, larva; *b*, female pupa; *c*, male pupa; *d*, *e*, male moth; *f*, female moth; *g*, male ovipositing; *h*, egg mass; *i*, male cocoons; *k*, female cocoons, with moths carrying eggs—all slightly enlarged (original).

figures. The newly hatched young feed on the under surface of the leaf, eating off the parenchyma and producing a skeletonized appearance. After the first molt the skeletonizing continues, but a few holes are eaten completely through the leaf; after the second molt many holes are eaten through between the main ribs, and after the third molt the leaf is devoured, except for the midrib and its principal branches. After the fourth molt the caterpillars begin to eat from the edge of the leaf and devour everything except the principal veins.

Similar work is done in the last stage upon the full-grown and tough leaves (see fig. 7).

A most peculiar kind of damage by the caterpillars of this species has been observed by Dr. Lintner in Albany, N. Y. There, in the summer of 1883, he found that the tips of many twigs were girdled by the caterpillars, which had entirely removed the bark for a tenth of an inch. Such twigs broke off and fell to the ground, with their leaves. This damage was so common in 1883 that the sidewalks of the streets and public parks wherever the American elm was growing were sprinkled with the newly fallen leaves. Dr. Lintner was of the opinion that a cold spring and the sudden advent of warm weather caused an unusually vigorous growth of the terminal twigs, and that the young tips were therefore unusually tender. They thus proved

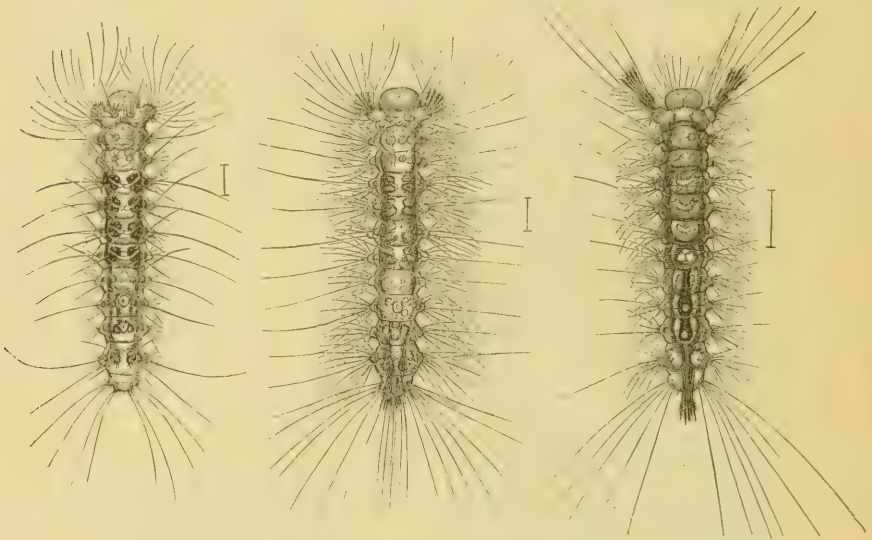


FIG. 5.—Tussock-moth caterpillar. First, second, and third stages—enlarged (original).

appetizing to the tussock-moth caterpillars, which developed a new habit for the occasion. This peculiar damage was repeated in 1895, but to a less extent. No other observer in any part of the country has ever reported similar damage.

The young caterpillars drop down, suspended by silken threads, at even a slight jarring of the tree, and frequently spin down without such disturbance, and are blown to a considerable distance by the wind. When nearly full grown they are great travelers, crawling down the trunk of the tree upon which they were hatched and across a considerable stretch of ground, to ascend another tree. When they occur in numbers, an extensive migration will always take place from a tree which has been nearly defoliated, and the species spreads mainly, if not entirely, in this way. Just as is the case with the gypsy moth,

the caterpillars are carried by vehicles upon which they crawl or drop, or upon the clothes of passers-by, and in this way many trees upon which there were no egg masses become infested.

The larval state lasts, on an average, from a month to five weeks. When full grown, the larvæ spin delicate grayish cocoons of silk mixed plentifully with hairs. The mixture of hair is brought about by the fact that the hairs are barbed and rather loosely attached to the body. When a caterpillar begins to spin its cocoon the hairs of its body and those of the long, black tufts on the prothorax first become entangled with the silken threads and are pulled out. By the time the cocoon has

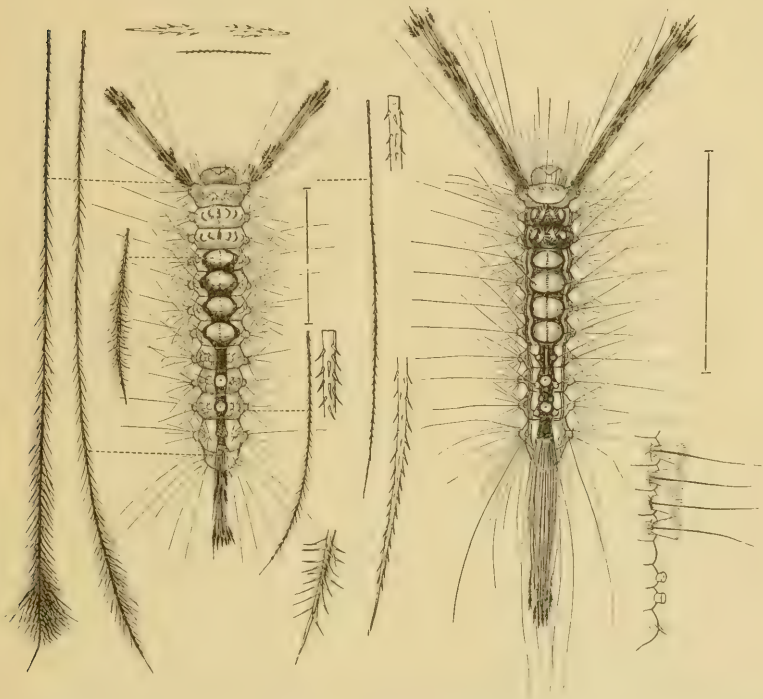


FIG. 6.—Tussock-moth caterpillar. Third and fourth stages, showing enlarged hairs from different parts of body (original).

begun to take shape, the characteristic long, black tufts of hair have entirely disappeared from the body of the caterpillar. Later the shorter hairs of the sides of the body become entangled and removed, and finally many of the hairs composing the brush-like tufts upon the fore part of the body are pulled out, and just before it transforms to pupa the caterpillar bears but a remote resemblance to the individual before it began to spin.

The barbed hairs just mentioned may occasionally produce considerable irritation of the skin of people upon whom the caterpillars may have crawled or dropped from the trees. The hairs from the different

portions of the body of the full-grown caterpillar are illustrated, greatly enlarged, in fig. 6, and it is the shorter hairs from the sides which probably cause the irritation. They are very small, fall out readily, and, when a caterpillar crawls over the skin of an individual who is warm and perspiring, these very sharply barbed hairs produce an irritation which in some individuals has been the cause of much discomfort, creating more or less inflammation and swelling.

The larva transforms to pupa within a few hours after the completion of the cocoon, and remains in the pupal condition from ten days to two weeks. The cocoons of this first generation, while mainly spun on the trunk and larger branches, are also spun to a very considerable extent upon the smaller branches and twigs, and even on the partly eaten leaves.

The adult insect presents the rather unusual phenomenon of a winged, active male and a degraded, absolutely wingless female. It is this fact which makes the spread of the species dependent upon the traveling powers of the caterpillar, as mentioned in the preceding paragraph. The male and female pupæ and the male and female moths are so well shown in fig. 4 as to need no description.

Coupling takes place upon issuing from the cocoon, and immediately afterwards the females begin to lay their eggs, clinging firmly to the cocoons from which they have issued and attaching the egg mass to the lower half of the cocoon, in the manner shown in fig. 4, *h* and *k*. As soon as the eggs are laid the females die, and usually fall to the ground, although sometimes their shriveled bodies remain clinging by the legs to the upper part of the cocoon.

We have made no observations as to the duration of these midsummer eggs. Unfortunately, upon the length of time which elapses before hatching depends exact information as to the number of annual generations. Specific observations in 1895 in Washington were not begun until August 15. At that time the egg masses were everywhere to be seen, and about that time the eggs began to hatch. From the early statements of Riley it was assumed that these were the eggs of the second generation, but reference to the notebooks of the office shows that on several occasions overwintered eggs have hatched in Washington in April, and adults have issued as early as the middle of June. From the middle of June to the middle of August is certainly long enough to allow for a generation of this insect. Assuming that such a generation had developed, larvæ from these August eggs would belong to the third generation.¹ This, however, is to a certain extent guess-work, and the regrettable lapse of observations during the last half of

¹ Observations made during 1896 confirmed fully the surmise here recorded that the white-marked tussock moth has at Washington three generations annually, instead of two, as previously stated by Riley. (See Bulletin 10, Division of Entomology, p. 33.)

June, the whole of July, and the first half of August could be remedied only in another season.

Elaborate observations were made upon this August brood in 1895, the individuals of which were present in extraordinary numbers. Certain of the larvæ under observation, which hatched on August 2, commenced to spin upon September 3, and on September 14 the first male moths made their appearance, the first females issuing September 19. During the latter part of September the bulk of the moths issued, and the conspicuous white egg masses were very abundant by the 1st of October. Many of these egg masses were kept under observation from that time on. In the cold room of the insectary (temperature the same as outdoors) a few eggs hatched about the close of the second week in October, and on October 23 two newly hatched larvæ were observed upon an egg mass collected out of doors. This late fall hatching, however, is probably exceptional, but in a late, warm autumn it is likely to be rather general. It is hardly to be supposed that any individuals hatching after the 1st of October will successfully transform. The cocoons of this late fall generation are almost invariably spun upon the trunk of the tree and in the crotches of the main limbs, but occasionally, in the case of large trees, upon the larger limbs themselves. The tendency of all the larvæ of this generation is to crawl toward the ground before transforming. Cocoons are occasionally spun upon fences or other objects near the trees upon which the larvæ have been reared, but the vast majority are found upon the trunks.

There are, then, certainly two, and probably three, annual generations at Washington.¹ In New York and Brooklyn there are two well-marked generations. At Boston, as is learned from Mr. Samuel Henshaw, there are two generations. Farther north, however, although the statement is based upon no exact observation, it is not at all likely that there are more than one, and, as stated in the introduction, the comparative harmlessness of the species in such regions is probably due to the nondevelopment of the second generation.

Remedies.—There are two classes of remedies as well as an excellent preventive that may be used to advantage against this insect. These are the collection or destruction of the eggs in the winter, spraying the trees against the larvæ, and banding unattacked trees to prevent the ascent of the caterpillars and the subsequent development of moths and the laying of eggs.

The collection and destruction, or the destruction without collecting, of the eggs must be thorough in order to have any practical efficacy. The great majority of the hibernating egg masses are deposited low down on the trunk of the tree or upon the main limbs, so that they can

¹ Certainly occasionally, and probably always; three, as indicated in the footnote on the preceding page.

be reached in one way or another without much difficulty. The egg mass is compact, and, being attached to the somewhat flimsy cocoon and not to the bark, it is easily removed either by hand or by scraping it off. The egg masses which have been scraped off must not be allowed to remain at the surface of the ground, but should be collected and burned. A scraper for the removal of egg masses which occur too high to be reached by hand has been devised by Mr. Southwick, of Central Park, New York City, and consists of a very small hoe blade at the end of a long pole. Perfectly unskilled labor can be utilized in this operation, but the workman should be impressed with the necessity of absolute thoroughness; not an egg mass should be overlooked.

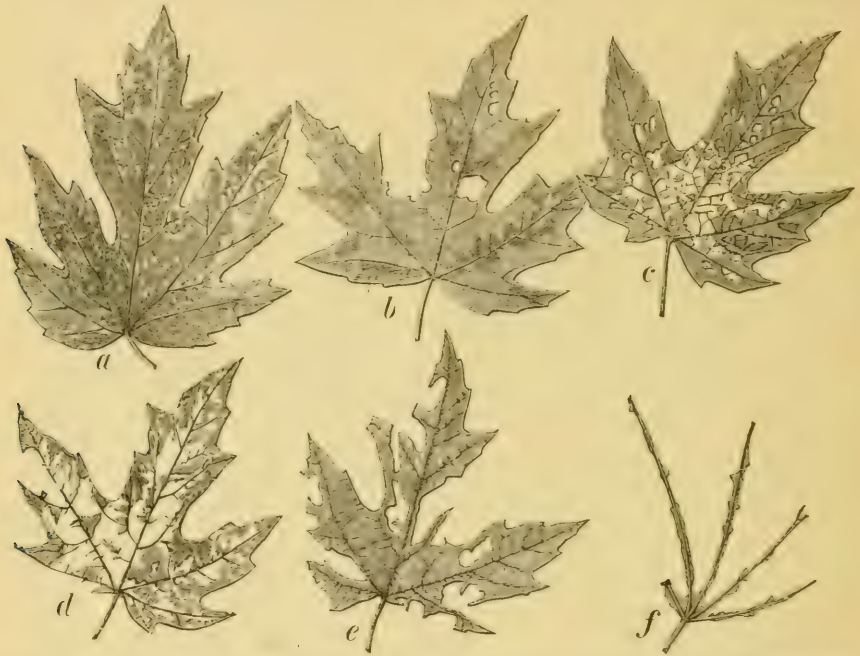


FIG. 7.—Silver maple leaves eaten by larvæ of white-marked tussock moth in successive stages of growth from *a* (newly hatched larvæ) to *f* (full-grown larvæ)—reduced (original).

In the work against the gypsy moth in Massachusetts it has been found that the egg masses can not be removed to the best advantage by means of scrapers. The eggs are attached, not to the cocoons, but to the bark of the trees, and certain eggs may be left in the attempt to remove the mass. An extensive series of experiments has therefore been carried on with a view to securing a liquid which will penetrate and destroy the egg masses.

A satisfactory liquid for this purpose has been found in creosote oil, to which turpentine is added to keep it liquid in cold weather, with tar to blacken it so that treated egg masses can be recognized at a glance.

The workman is furnished with a pole, to the end of which a small sponge is tied. He goes from tree to tree, dipping the sponge occasionally into the creosote preparation and touching with it each egg mass found. This is a simple and very rapid method. It has the advantage of rapidity over the scraping method described above, since after the eggs are scraped off they must be collected and carried away for burning.

A modification of this plan may be used to advantage against the tussock moth. The pure white color of the egg mass of the tussock moth, however, renders the use of coal tar in the preparation unnecessary, since the creosote oil alone will discolor it enough to render a treated mass recognizable at a distance.

No explicit directions for spraying with arsenical poisons against this insect are needed. The same liquid and the same apparatus that

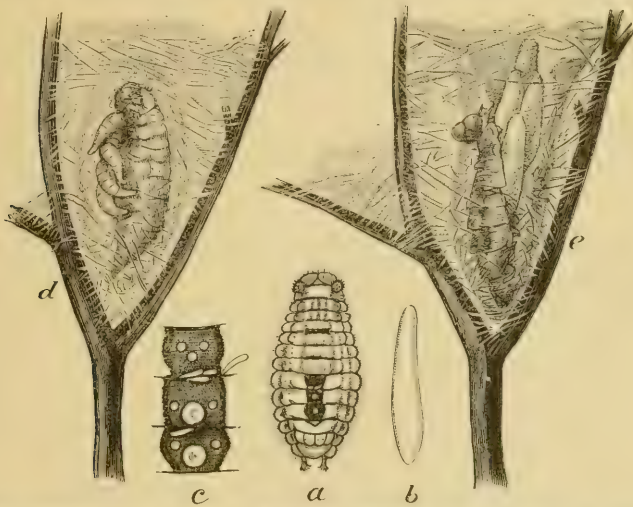


FIG. 8.—*Pimpla inquisitor*, an Ichneumonid parasite of tussock-moth caterpillar. *a*, parasitized caterpillar; *b*, egg of parasite; *c*, same *in situ*; *d*, parasite larvæ issuing; *e*, parasite cocoons—all slightly enlarged, except *b* and *c*, which are much enlarged (original).¹

are used against the elm leaf-beetle may be used against this insect, and the spraying may be done at about the same time of the year. It is essential that the caterpillars of the first generation shall be killed, as the second and more destructive brood will thus be prevented.

Banding of the trees is practiced to advantage with this species. It is the only one of the shade-tree insects, except the bagworm, which has a wingless female. All the others, except the gypsy moth, spread

¹See Bulletin 5, technical series, Division of Entomology, and Bulletin 9, new series, pages 15-17, for an extended account of the parasites of this species. The injurious outbreak of 1895 was checked in the most perfect manner by these parasites, so that the tussock moth was hardly to be noticed during the latter part of 1896, or during 1897 or 1898.

from tree to tree by the flight of the female. Many experiments have been made with different styles of bands, and it has been practically proved that a broad, thick strip of raw cotton, tied about the trunk of the tree with a string, is after all the most efficacious and perhaps the cheapest. Such bands have to be renewed occasionally, as they become more or less matted together and spoiled by rainstorms.

Next in point of efficacy will probably come bands of insect lime, several brands of which are on the market. Insect lime is a sticky, coal-tar product, which retains its visciduity for a considerable time. A ring made around a tree will remain operative for some weeks in warm weather.

THE FALL WEBWORM.

(*Hyphantria cunea* Drury; figs. 9 to 11.)

Associated with the white-marked tussock moth in its damage to the shade trees of the city of Washington during the summer of 1895, were very many specimens of the fall webworm; in fact, this insect was more abundant during the summer of 1895 than it has been in Washington since 1886. It was not as numerous and destructive as the white-marked tussock moth, and the last generation was so extensively parasitized as to lead to the anticipation that the species would not be especially abundant during 1896.

The fall webworm is a typical American species. It is found from Canada to Georgia and from Montana to Texas. It is an almost universal feeder, and the records of the Division of Entomology list about 120 species of shade and ornamental trees, as well as fruit trees, upon the leaves of which it feeds.

In the District of Columbia and north to New York City there are two generations annually, as is the case with the tussock moth. In more northern localities, where it is single-brooded, it loses its place as a species of great importance. It hibernates as a pupa within a cocoon attached to the trunk of its food plant, or to tree boxes, neighboring fences, or to rubbish and sticks or stones at the surface of the ground. The different stages of the insect are shown in figs. 9 to 11. The moth, which may be either pure white or white spotted with black, flies at night and deposits a cluster of 400 or 500 eggs, upon either the upper or the under surface of the leaf. The caterpillars feed gregariously, and each colony spins a web which may eventually include all the leaves of a good-sized limb. Reaching full growth, the caterpillars leave the web and crawl down the trunk of the tree to spin their cocoons. The caterpillars of the second generation begin to make their appearance in force in August.

Remedies.—On account of the fact that the adult female is an active flier, we can use against the fall webworm but two of the remedies suggested for use against the tussock-moth caterpillars, namely, spraying with arsenical poisons and the collection of the cocoons. The gre-

garious habit of the larvæ, however, suggests another remedy which is practical and very efficient if thoroughly carried out. This is the destruction of the webs and the contained larvæ, either by cutting off the twigs which carry them and burning immediately, or burning the webs without pruning. If this work be done properly and against the early summer generation, the pruning method is unnecessary and inadvisable. By the use of a proper torch the webs and the caterpillars which they contain can be burned off at nightfall without necessarily destroying the life of the twigs, and a second crop of leaves will be put out a little later, so that the tree does not remain disfigured for any length of time. A bundle of rags wired to the end of a pole and saturated with kerosene makes a good torch for the purpose; or a porous brick wired to a pole and saturated with kerosene answers the purpose even better. Private persons will find this remedy sufficient. City authorities should apply an arsenical spray. Collecting the cocoons in winter may be carried on simultaneously with the collection of the egg masses of the white-marked tussock moth, but this, as well as other community remedies, will be referred to at another place.

THE RELATIVE IMMUNITY FROM INSECTS OF DIFFERENT VARIETIES OF SHADE TREES.

As regards a number of the principal shade trees that are most commonly grown, there does not seem to be any great preference on the part of the fall webworm and the tussock-moth caterpillar. If a moth happens to lay her eggs upon or near a given tree standing in a row, the species will naturally spread along the row before it will cross to the opposite side. In this way erroneous ideas of the relative immunity of trees have frequently been gathered. •

Taking the insect question as a whole, however, there is a decided difference in the relative value of certain varieties. In December, 1893, the Tree Planting and Fountain Society of Brooklyn asked a number of experts to name for the use of the society nine of the most valuable trees for planting in Brooklyn. Three of these trees were to be large-growing, three medium-sized, and three small-growing varieties.

The reply of Mr. B. E. Fernow, Chief of the Division of Forestry in the United States Department of Agriculture, was comprehensive and of great value. He tabulated nearly 50 varieties, analyzing their good qualities under the different heads of endurance, recuperative power, cleanliness, beauty of form, shade, leaf period, rapidity of growth, and persistence, giving 3 as the highest mark for any one of these qualities and estimating the value of a given tree by the total number of marks given to it. This reply was printed and issued as a circular by the Brooklyn society. Mr. Fernow made no specific rating for immunity from insect pests, although in his introductory remarks he seems to have included the insect question under the head of cleanliness.

As is quite to be expected, the rating arrived at from the summing up of the qualities mentioned differs very considerably from the rating which might be arrived at from the quality of immunity from insects. Taking the large and medium-sized trees only (36 species in all), Mr. Fernow's rating stands as follows, only the total gained by the addition of the ratings in the several qualities considered being given:

Variety of tree.	Total rating (Fernow).	Insect rating (Howard).
LARGE-SIZED TREES.		
Red oak (<i>Quercus rubra</i>)	22	2.5
Scarlet oak (<i>Quercus coccinea</i>)	22	2.5
Yellow oak (<i>Quercus velutina</i>)	22	2.5
American elm (<i>Ulmus americana</i>)	22	1.5
Sugar maple (<i>Acer saccharum</i>)	19	2.5
Black maple (<i>Acer nigrum</i>)	19	2.5
Tulip tree (<i>Liriodendron tulipifera</i>)	19	3.0
European linden (<i>Tilia vulgaris</i>)	19	1.5
Small-leaved linden (<i>Tilia microphylla</i>)	19	2.0
Sweet gum (<i>Liquidambar styraciflua</i>)	19	2.0
White oak (<i>Quercus alba</i>)	19	2.0
Bur oak (<i>Quercus macrocarpa</i>)	19	2.0
Oriental plane tree (<i>Platanus orientalis</i>)	19	1.5
Kentucky coffee tree (<i>Gymnocladus divisius</i>)	19	2.0
American plane tree (<i>Platanus occidentalis</i>)	18	1.5
Sycamore maple (<i>Acer pseudo-platanus</i>)	17	2.0
American linden (<i>Tilia americana</i>)	17	1.5
MEDIUM-SIZED TREES.		
Red maple (<i>Acer rubrum</i>)	22	2.0
Shingle oak (<i>Quercus imbricaria</i>)	21	2.0
Willow oak (<i>Quercus phellos</i>)	21	2.5
Slippery elm (<i>Ulmus pubescens</i>)	21	2.0
Norway maple (<i>Acer platanoides</i>)	20	2.0
Box elder (<i>Negundo negundo</i>)	20	.0
European elm (<i>Ulmus campestris</i>)	19	.5
Scotch elm (<i>Ulmus montana</i>)	19	1.0
Hackberry (<i>Celtis occidentalis</i>)	19	1.5
Silver-leaved maple (<i>Acer saccharinum</i>)	17	1.5
Tree of heaven (<i>Ailanthus glandulosa</i>)	16	2.5
Horse chestnut (<i>Esculus hippocastanum</i>)	16	2.0
Japanese sophora (<i>Sophora japonica</i>)	16	2.5
Hardy catalpa (<i>Catalpa speciosa</i>)	16	2.0
Ginkgo (<i>Ginkgo biloba</i>)	16	3.0
Honey locust (<i>Gleditsia triacanthos</i>)	15	1.0
Cottonwood (<i>Populus monilifera</i>)	15	.5
Balm of Gilead (<i>Populus balsamifera</i> v. <i>candicans</i>)	15	.5
Black locust (<i>Robinia pseudacacia</i>)	14	.5

The writer has made ratings of these same trees according to their immunity from the attacks of insects, the trees most immune being rated at 3 and those most attacked by insects at 0. The figures relating to insect attack are displayed above in a contrasted column next to the total rating, and in order that the relative importance from the

insect standpoint may be seen at a glance the same trees have been rearranged in a separate table as follows:

Variety of tree.	Insect rating.	Variety of tree.	Insect rating.
Gingko (<i>Ginkgo biloba</i>)	3.0	Shingle oak (<i>Quercus imbricaria</i>).....	2.0
Tulip tree (<i>Liriodendron tulipifera</i>)	3.0	Slippery elm (<i>Ulmus pubescens</i>).....	2.0
Sugar maple (<i>Acer Saccharum</i>)	2.5	Norway maple (<i>Acer platanoides</i>).....	2.0
¹ Red oak (<i>Quercus rubra</i>)	2.5	Hardy catalpa (<i>Catalpa speciosa</i>)	2.0
Tree of heaven (<i>Ailanthus glandulosa</i>) ..	2.5	European linden (<i>Tilia vulgaris</i>).....	1.5
¹ Scarlet oak (<i>Quercus coccinea</i>)	2.5	American elm (<i>Ulmus americana</i>).....	1.5
Yellow oak (<i>Quercus velutina</i>)	2.5	Hackberry (<i>Celtis occidentalis</i>).....	1.5
Willow oak (<i>Quercus phellos</i>)	2.5	Silver-leaved maple (<i>Acer saccharinum</i>) ..	1.5
Black maple (<i>Acer nigrum</i>)	2.5	Oriental plane tree (<i>Platanus orientalis</i>) ..	1.5
Japanese sophora (<i>Sophora japonica</i>) ..	2.5	American plane tree (<i>Platanus occi-</i>	
Horse-chestnut (<i>Æsculus hippocasta-</i>		<i>dentalis</i>)	1.5
<i>num</i>)	2.0	American linden (<i>Tilia americana</i>) ..	1.5
Red maple (<i>Acer rubrum</i>)	2.0	Honey locust (<i>Gleditschia triacanthos</i>) ..	1.0
Small-leaved linden (<i>Tilia microphylla</i>) ..	2.0	Scotch elm (<i>Ulmus montana</i>)	1.0
White oak (<i>Quercus alba</i>)	2.0	Cottonwood (<i>Populus monilifera</i>).....	.5
Sweet gum (<i>Liquidambar styraciflua</i>) ..	2.0	Balm of Gilead (<i>Populus balsamifera</i> v.	
Bur oak (<i>Quercus macrocarpa</i>)	2.0	<i>candicans</i>).....	.5
Kentucky coffee tree (<i>Gymnocladus</i>		European elm (<i>Ulmus campestris</i>)	.5
<i>divisus</i>)	2.0	Black locust (<i>Robinia pseudacacia</i>)	.5
Sycamore maple (<i>Acer pseudo-platanus</i>) ..	2.0	Box elder (<i>Negundo negundo</i>)	.0

¹ This estimate of the red oak and scarlet oak was based largely on the beautiful condition of certain trees growing in the streets of Washington, D. C. Since the publication of the Yearbook article, however, several of these trees have developed rather serious cases of insect injury. The locust borer (*Xyletus robinia*) has attacked a number of the trees, and although it is not apparently weakening their vitality to any serious extent, still it bids fair to do considerable damage. The trees have been treated by injecting a small quantity of bisulphide of carbon into the burrows and covering the opening with putty. In a few cases the obscure scale (*Aspidiotus obscurus*) has attacked these trees. It has not as yet killed any branches, but it multiplies as abundantly as its dangerous relative, *A. tenebricosus*, of the maple, and I see no reason why it should not be an equally injurious species. This experience somewhat shakes the confidence of the writer in his estimate of the rating of these oaks, but not to any very serious extent.

It will be noticed that the trees listed by Mr. Fernow which we find to be most immune are the gingko and the tulip tree. Outside of the grounds of the Department of Agriculture at Washington and Central Park, New York, few gingko trees are grown in this country, except as occasional isolated examples. The tree itself is a very beautiful one, and singularly free from insect attack. In the long double row of these trees, now nearly twenty-five years old, on the grounds of the Department of Agriculture, but one species of injurious insect has ever been found, and the work of this species is very insignificant. It is the little sulphur-yellow leaf-roller, *Tortrix sulphureana*.

The tulip tree, which is given the same rating, is, for practical purposes, almost as exempt as the gingko. Of late years in the District

of Columbia it has been rather extensively infested by a plant louse (*Siphonophora liriodendri*), but although the lice occur on the leaves in great numbers, the general appearance of the trees has not suffered. There is a little gall midge which produces little black spots on the tulip tree leaves and disfigures them to some extent, and quite recently Mr. Schwarz has found that tulip scrub is affected to some extent in the District of Columbia by a little bark-boring beetle.

The box elder is a singularly unfortunate choice for a shade tree in this climate. It is almost defoliated by the webworm, it is sought after by the tussock moth, and various leaf-rollers attack it as well as

certain destructive borers. In the West the box-elder plant-bug (*Leptocoris trivittatus*) breeds upon it in enormous numbers, and not only damages the trees to a serious extent, but causes much further annoyance by entering houses for hibernation.

The European elm is given a low rank, almost entirely on account of its annual defoliation by the imported elm leaf-beetle.

The honey locust and the black locust, while not defoliated to the same extent as many other trees by the webworm and the tussock-moth caterpillar, are rendered very unsightly almost every year by the work of a leaf-mining Hispid beetle and of certain Lepidopterous leaf miners. They are also fre-



FIG. 9.—Fall webworm (*Hyphantria cunea*). Moths and cocoons—natural size (original).

quently killed by the large Lepidopterous borer, *Xyleutes robinia*, and certain Coleopterous borers also infest them.

From the insect standpoint, there are several fine-growing ornamental trees on the grounds of the Department of Agriculture, not listed above, which are seldom attacked by insects. The beeches, hornbeams, alders, and magnolias have very few insect enemies, and are rarely defoliated by either of the principal leaf-eating caterpillars.

With regard to the extreme attractiveness which the European elm possesses for the imported elm leaf beetle, the question is frequently asked whether it would not be better to cut down all European elms

growing in parks or in rows with American elms. Such a course, however, would seem to be undesirable. After the elm leaf-beetle has established itself in a given locality, it will attack the American elms to a very serious extent, in the absence of its favorite food plant. It is, therefore, better to allow a few European elms to remain. These will then act as trap trees, and the necessity for treating a large number of trees will in most cases be greatly reduced.

In selecting shade trees, particularly for small cities and towns in agricultural regions, and even to a considerable extent in large cities, the relative honey-producing qualities of the proposed shade trees is a matter of some little importance; not so much, perhaps, in the matter of actual food for the ordinary honeybee as in that of the increase of bees on account of their great value as cross fertilizers of orchard trees and forage crops. From this point of view, there are five very important honey producers among the principal shade trees. These are, in order of importance: American linden, tulip tree, black locust, horse-chestnut, and sugar maple.

GENERAL WORK AGAINST SHADE-TREE INSECTS IN CITIES AND TOWNS.

The question of proper work against the insects which affect shade trees in cities and towns naturally divides itself under two heads: (1) What can be efficiently and economically done by city governments? (2) If city or town administrators will not appropriate a small amount of money to carry on work of this kind, what can citizens who are interested in the preservation of shade trees do?

The planting of shade trees seems to be considered a legitimate function of the board of public works in every municipality. It is sometimes done by a specially appointed officer, under the control of the superintendent of streets and sewers; or it is placed in charge of a subcommittee of the board, or a special commission of outsiders is appointed to superintend the work. Admitting that the planting of shade trees is a public matter, their care should also be a public duty. Yet in not one of the larger or smaller cities of the Eastern United States with which the writer is familiar is any proper amount of work done by the public authorities against shade-tree insects. New York is the only city in the country where a man of entomological knowledge is employed to direct operations against shade-tree insects, either in the streets or the public parks. The writer does not wish to be understood as advocating the appointment of a paid entomologist by every city government, although where the parks are large in cities situated within the region of greatest shade tree insect activity, such a course is always desirable. With an intelligent and industrious superintendent of parks, or a city forester, or whatever he may be termed, and the wise expenditure of a comparatively small amount of money each year,

the shade trees of any city could be kept green throughout the summer.

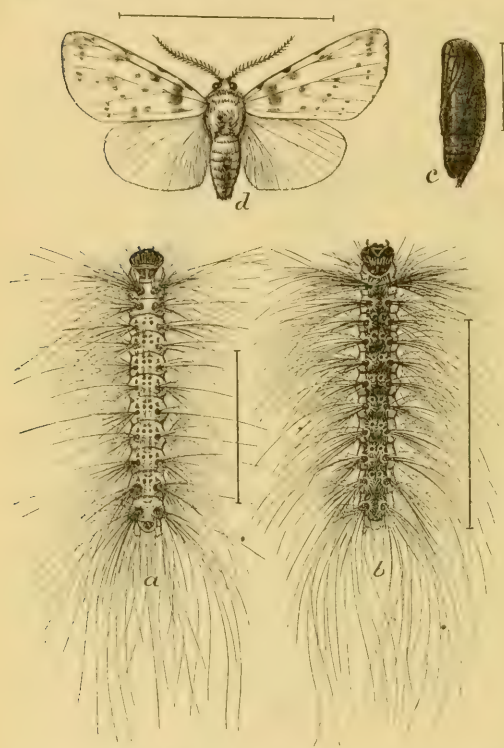
The amount of money to be expended in this direction would naturally vary with the number of trees to be attended to, as well as with the variety and the size of the trees and the geographical location of the city. Even in Brooklyn, however (and this seems to the casual observer to be the most unfortunate of all our Eastern cities from this standpoint), it is within bounds to estimate that the expenditure of \$4,000 to \$5,000 a year would result in green shade trees the summer

through. This amount, moreover, will in all probability not need to be an annual appropriation. The first cost of a proper spraying apparatus will have to be added, but the apparatus once purchased and thorough work performed for two or three years consecutively, the probabilities are strong that the number of shade-tree insects would be reduced to such an extent that a considerably smaller annual expenditure would be sufficient.

The question of proper spraying apparatus is a rather serious one, since in this direction a considerable amount of money should be expended. A steam apparatus will do the work with much greater rapidity than a hand pump; and yet with a strong,

double-acting force pump, which can be operated by a single man, and a tank of 100 gallons capacity, mounted upon a strong cart, many large trees can be well sprayed in the course of a day. From such a pump two lines of hose may be run with advantage.¹ The working force of such an apparatus should be a horse to draw the cart, a man to drive and do the pumping, and one man to each line of hose. Several such machines

FIG. 10.—Fall webworm. *a*, light form of full-grown larva; *b*, dark form of same; *c*, pupa; *d*, spotted form of moth (compare fig. 9)—all slightly enlarged (original).



¹ In the Yearbook of this Department for 1896 will be found an article by the writer entitled "The use of steam spraying apparatus," to which persons interested in such matters are referred in this connection.

have been used with good results in the work of the Gypsy Moth Commission, both for street trees and in the public parks. A steam apparatus, however, of such a capacity that a pressure of 75 pounds per square inch may be gained will enable the operation of four or five lines of hose simultaneously. The rapidity of work will therefore be doubled, and certainly by the use of two such pumps the shade trees of any ordinary city can be gone over with sufficient rapidity to destroy all insects within the required time. A boiler mounted on a truck, the boiler to be complete with all fixtures, smokestack, bonnet, firing tools, springs to the truck, and a pump having a capacity of 10 to 20 gallons a minute connected with the boiler ready for operation, can be purchased for a sum well within \$500. This truck should be mounted on wheels with broad tires, for running over sandy roads. Connecting

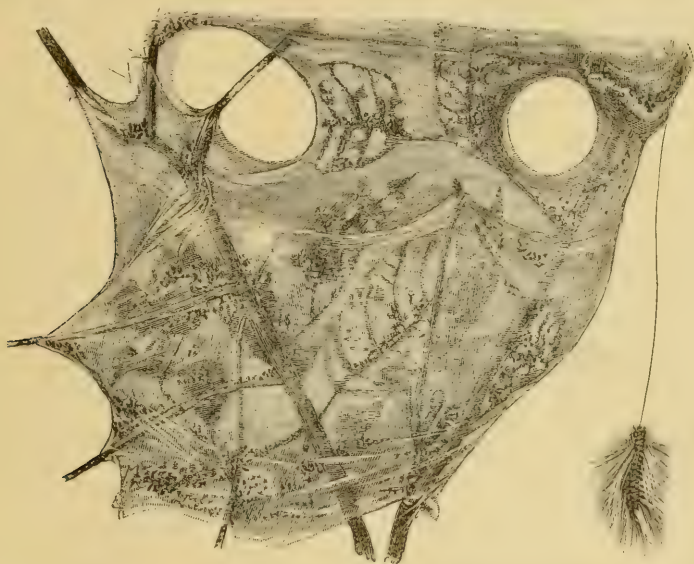


FIG. 11.—Fall webworm. Suspended larva and section of web—natural size (original).

this apparatus with a proper tank cart would be an additional expense, not to exceed \$100 for a tank of a capacity of 200 gallons. Such an apparatus, furnished with hose and smoothbore nozzles of about one-sixteenth inch in diameter, when discharging under 40 pounds pressure from each of several such nozzles, would spray about half a gallon of insecticide mixture per nozzle per minute.

A strong steam pump, to be used in connection with a small oil-burning boiler, the whole apparatus on a smaller scale than that described above, has been estimated at \$275 by a prominent New York firm, delivered on board the cars.

There is no reason why an old steam fire engine could not be readily arranged for this shade-tree spraying work. In one or two instances a steam fire engine has been used for this purpose without

modification, the object being simply to knock the insects from the trees by means of a strong stream of water. By such means as this the Superintendent of the Military Academy kept the elm trees green at West Point several years ago. In every large city, where the fire department is necessarily kept in the best condition, an engine is occasionally retired. The transfer of such a retired engine to the street department could no doubt be readily made, and a little work by a competent steam fitter could transform it into a most admirable insecticide machine. In this way the initial expenditure for machinery would be avoided.

When the spraying apparatus has once been provided, the funds necessary for the purchase of insecticides and the necessary labor at the proper time must be available. If the work is not done promptly and at just the right time, more or less damage will result, and a greater expenditure will be necessary. During the latter part of May and the first part of June, in the case of nearly all prominent shade-tree insects, one or two thorough sprayings must be made. In fact, a second spraying, begun immediately after the completion of the first one, will in ordinary cases be as much as need be expected. In addition to this spraying work, a force of men must be employed for a time in July to destroy the elm leaf-beetle larvæ as they are descending to the ground and to burn the webs of the first generation of the fall webworm. This will finish the summer work. The winter work will consist of the destruction of the eggs of the white-marked tussock moth, the cocoons of the fall webworm, and the bags of the bagworm. The number of men to be employed and the time occupied will depend upon the exigencies of the case. Upon the thoroughness of this work will depend, to a large extent, the necessity for a greater or less amount of the summer work just described.

We have now to consider what can be done by citizens where city governments will not interest themselves in the matter. It is unreasonable to expect that a private individual will invest in a spraying apparatus and spray the large shade trees in front of his grounds. Therefore, in spraying operations where large trees exist in numbers there must be combination of resources. This affords an opportunity for the newly invented business of spraying at so much per tree. A resident of Bridgeport, Conn., who was formerly, and is yet for the greater part of the year, a roofer and paver, has constructed several cart sprayers, and during the months of June and July (at a time, by the way, when the men in his employ are apt to be out of work) he sprays trees on the grounds of private individuals and along the streets in front of their grounds, under contract, at so much per tree, guaranteeing to keep the trees in fair condition during the season. His work has been directed solely against the elm leaf-beetle, since that is the only insect of great importance in Bridgeport. In the month of July, 1894, the writer, in driving through the streets of

Bridgeport, found it easy to pick out the trees which had been treated in this way. Such elms were green, while all others were brown and nearly leafless. The defect of this plan as a general practice lies in the fact that not all property owners or residents can afford to employ a tree sprayer, while others are unwilling, since they deem it the business of the city authorities, or do not appreciate the value of tree shade.

Any effort, therefore, looking toward the arousing of popular sentiment or the banding together of the citizens in the interests of good shade is desirable. A most excellent plan was urged by one of the Washington newspapers in the summer of 1894. It advocated a tree-protection league, and each issue of the paper through the summer months contained a coupon which recited briefly the desirability of protecting shade trees against the ravages of insects, and enrolled the signer as a member of the league, pledging him to do his best to destroy the injurious insects upon the city shade trees immediately adjoining his residence. This is only one of several ways which might be devised to arouse general interest. The average city householder seldom has more than a half dozen street shade trees in front of his grounds, and it would be a matter of comparatively little expense and trouble for any family to keep these trees in fair condition. It needs only a little intelligent work at the proper time. It means the burning of the webs of the fall webworm in May and June; it means the destruction of the larvæ of the elm leaf-beetle about the bases of elm trees in late June and July; it means the picking off and destruction of the eggs of the tussock moth and the bags of the bagworm in winter, and equally simple operations for other insects should they become especially injurious. What a man will do for the shade and ornamental trees in his own garden he should be willing to do for the shade trees 10 feet in front of his fence.

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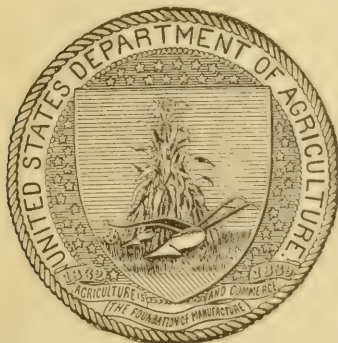
FARMERS' BULLETIN No. 120.

THE PRINCIPAL INSECTS AFFECTING THE TOBACCO PLANT.

BY

L. O. HOWARD,
ENTOMOLOGIST.

[Reprinted, with slight revision by the author, from the Yearbook of the
Department of Agriculture for 1898.]



WASHINGTON:
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1900.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., July 18, 1900.

SIR: I have the honor to transmit herewith a copy of an article contributed by me to the Yearbook for 1898, entitled "The Principal Insects Affecting the Tobacco Plant." I have made some slight changes in it, so as to bring the matters treated up to date, and recommend that it be republished as a Farmers' Bulletin.

Respectfully,

L. O. HOWARD, *Entomologist*.

Hon. JAMES WILSON, *Secretary of Agriculture*.

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THE PRINCIPAL INSECTS AFFECTING THE TOBACCO PLANT.

INTRODUCTION.

The tobacco plant, although indigenous to America, does not suffer so greatly from the attacks of insects in the United States as do others of our crop plants. It has no insect enemies peculiar to itself, but every season a certain amount of damage is done by insects, and in some years favorable to insect increase this damage may mean a serious loss to the planter.

The most comprehensive work upon tobacco insects which has been published is in the Italian language, and includes a consideration of all species which affect this crop, both in the field and in the factory. But this work treats largely of European insects, being a special report of the entomological agricultural experiment station at Florence, entitled "Animals and insects of growing and dried tobacco," by Prof. A. Targioni-Tozzetti. In this country there have been occasional accounts of specific insects in the different agricultural reports and in the bulletins of the State experiment stations. Prof. H. Garman, of the Kentucky experiment station, in particular, has given the subject much attention, and has done admirable work in the important direction of proving the possibility of the practical use of arsenical mixtures on the tobacco plant. The most comprehensive article which has yet been prepared in this country is one printed by the Florida Agricultural Experiment Station as Bulletin No. 48, with the title "A preliminary report upon the insect enemies of tobacco in Florida," by A. L. Quaintance.

The present paper contains accounts of several tobacco insects not included in the bulletin by the Florida author, who, as the title indicates, treats only of the species occurring in Florida, but the writer defers to Professor Quaintance in matters of actual field experience concerning several of the species, and wishes here to express his thanks for advance proof sheets of the bulletin in question, which have enabled him to make this paper more complete than it would otherwise have been.

From the time when the seed is sown in the seed bed to the time when the tobacco field is plowed under to some late fall crop, the

tobacco plant is subject to the attacks of several species of insects. Throughout the tobacco-growing regions of the United States there is probably no one insect which does more damage to the marketed product than the tobacco flea-beetle, or "flea bug," as it is commonly known to growers (*Epitrix parrula*). The large horn worms or "horn-blowers," also insects of wide distribution, tobacco growers must always fight. The bud worm, which may be either the larva of *Heliothis rhexia* or of the cotton boll worm or tomato fruit worm or corn-ear worm, as it is called according as it affects different plants (larva of *Heliothis armiger*), attacks and bores into the central leaf roll or "bud" early in the summer, or later in the season into the seed pods or into the terminal flower stalk, and even feeds to a certain extent upon the leaves. Several species of cutworms are liable to occasion replanting in soil which has not been properly treated, and one or two of them rag the leaves late in the season. Certain wireworms also are liable to affect the young plant shortly after it is set out. Two or more species of plant bugs occasionally damage the leaves by inserting their beaks and sucking the juices, causing a drying and shriveling of the leaf in much the same way as the harlequin cabbage bug injures the leaves of cabbage. One of these plant bugs, a small species, insignificant in appearance, has recently proved to be a serious enemy to tobacco culture in Florida. Another new insect, and one which may prove to be a very important factor in tobacco culture, is the so-called tobacco leaf-miner, or "split worm," an insect which although first found in North Carolina only two years ago has since made its appearance in Florida, South Carolina, and southern Virginia. These comprise the principal species damaging growing tobacco at the present time. There is always a chance, however, that new insect enemies may make their appearance just as two of those above mentioned have done in very recent times, and it is safe to say that many of the species which affect solanaceous plants, and especially the tomato, are liable to transfer their attentions to the tobacco crop under favorable conditions.

After the tobacco has reached the factory, an insect enemy of importance, and which is always to be feared, is the cigarette beetle (*Lasioderma serricorne*), a species which riddles the tobacco leaf, which bores into or out of manufactured cigarettes and cigars, and which, when once introduced into a not over cleanly factory, is very difficult to eradicate. Two or three other little beetles have been found in dried tobacco, namely, the drug-store beetle (*Sitodrepa panicea*) and the rice weevil (*Calandra oryza*), but they are not as important as the cigarette beetle.

It is proposed to give in this bulletin a short account of these insects and other species of less importance, with some indication of the proper remedies under each, and a concluding paragraph on remedial work as a whole.

THE TOBACCO FLEA-BEETLE.

(*Epitrix parvula* Fabr.)

This active little insect (fig. 1) may be found in almost any tobacco field from Arkansas to Florida and north to Connecticut. It is a minute, oval, reddish-brown species, which occurs upon many solanaceous plants, feeding upon tomato, potato, horse nettle, and jimson weed (*Datura stramonium*). The beetles make their appearance in July, attacking first the lower and then the upper leaves. After they have fed for awhile the leaf becomes full of small, dry spots and then of holes about the size of a pin point, which later may become considerably enlarged (fig. 2). When the crop is cured it is poor and thin, and frequently full of small holes. While the main damage is done in the beetle condition, the insect feeds also, in its early stages, upon the tobacco. Its eggs being laid at the roots, hatch into minute, whitish larvæ, which feed upon the roots, and, in the course of about a month, as ascertained by Mr. Chittenden, reach full growth, transform to pupæ, and again to adult beetles. The damage done to the roots in this way must affect the health of the plant to a certain extent, but it is not appreciable in comparison with the damage which the adult beetles do to the leaves.

The insect, in its early stages, is not confined to tobacco, but feeds also upon the nightshade and the jimson weed, as also ascertained by Mr. Chittenden.

It is not alone in the actual damage to the leaves done by the jaws of the beetle that this insect is injurious to the foliage of tobacco, but through the further fact that these little holes, even when the puncture is not through the entire thickness of the leaf, become the entrance points of fungous spores or bacteria, which start a disease of the leaf which frequently damages it much more than the insects themselves. In moist weather this disease, started by the flea-beetles, may do considerable damage when the flea-beetles themselves are comparatively scarce.

By some writers the round white spots in the leaves, which are illustrated in fig. 3, have been considered to result from the initial work of the tobacco flea-beetle; but, as reported by several workers upon fungous diseases, these spots have been shown to be invaded by

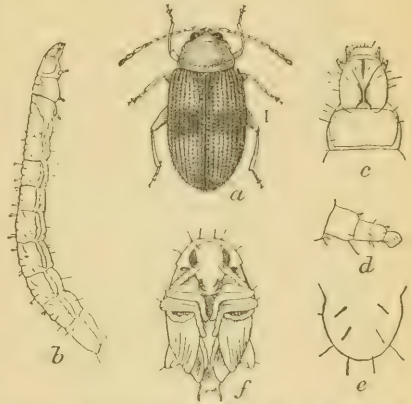


FIG. 1.—*Epitrix parvula*: a, adult beetle; b, larva, lateral view; c, head of larva; d, posterior leg of same; e, anal segment, dorsal view; f, pupa—a, b, f enlarged about fifteen times, c, d, e more enlarged (after Chittenden).

a species of fungus belonging to the genus *Cercospora*, members of which actually cause leaf diseases upon other plants, and which are certainly capable of damaging leaves in this way without the preliminary insect work. The commonest form of this damage seems to be caused by *Cercospora nicotinae*, and is known as "frog eye" or "white

speck." Another similar disease known by the same names occurs in Florida, and another in Europe, where it is known as "smallpox." The "white speck" of the North Carolina planters is said by Ellis and Everhart to be caused by a fungus known as *Macrosporium tabacinum*. Although not proved, it is quite possible that the tobacco flea-beetle is more or less responsible for, if not the occurrence, at least the spread of these diseases. There is a fad for cigar wrappers spotted in this way. A patent on an artificial method of imitating these disease spots has lately been issued.

The writer has visited tobacco fields in Virginia in which almost every plant was more or less affected by the tobacco flea-beetle. The upper leaves were spotted by their work, particularly near the edges, and the lower leaves were riddled with holes and almost covered with the white fungous spots.

REMEDIES.

Reference will be made later in this bulletin to the advantage of clean cultivation in the tobacco fields. The destruction of weeds, particularly solanaceous weeds, along the margins of the field, will be of positive benefit in reducing the numbers of this insect, as well as other tobacco insects, unless (and this suggestion we make as one of much possible value) it shall be found feasible to grow a few clumps



FIG. 2.—Tobacco leaves damaged by *Epitrix parvula* (original).

of nightshade or jimson weed as trap crops for the beetles, the plants to be thoroughly poisoned in the early summer before the tobacco has been set out. The tobacco crop is one of a few which are peculiarly adapted to this kind of remedial treatment. In the ordinary course of tobacco culture the weeds are allowed to grow freely about the margins of the fields. Before the tobacco plants are set out, those

weeds which are secondary food plants of tobacco insects, such as *Solanum nigrum*, *Solanum carolinense*, and *Datura stramonium*, act simply as concentrators and multipliers of the tobacco insects, so that the insects are already in force about the margins of the fields, ready to transfer their attentions to the young and succulent tobacco plants after they have been planted. From this it is plain that, if the margins of the fields are kept free from such plants, the insects will not have as good a start, and will not be present in such great numbers. It also follows that, if a few attractive weeds are left in clumps, the flea-beetles and other tobacco insects of the immediate vicinity will concentrate upon these few weeds, where they can readily be killed, either by the application of an arsenical poison, if they are gnawing insects, or of a kerosene emulsion, if they are sucking insects.

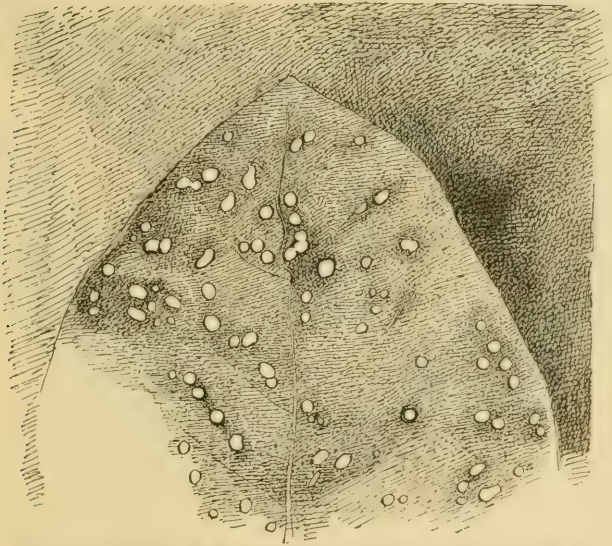


FIG. 3.—Leaf spots of old tobacco leaf—slightly reduced (original).

Where preliminary work of this nature has been neglected, and it becomes necessary to treat the tobacco flea-beetle in the tobacco field, we are prepared to heartily recommend the use of arsenical poisons. Small as the insect is, and much as its initial work looks like the puncture of a beak rather than the nibbling of a pair of jaws, it is a true biting or gnawing insect; therefore, if the leaves be treated, even with a minute quantity of an arsenical poison, the insect will be reached by it in the act of eating the leaf, and will be destroyed. This is not as satisfactory a means of killing the insect as the preventive mentioned above, for the reason that, in order to get its dose of the poison, the insect must damage the leaf to a certain extent, and as there is a constant succession of new beetles, the leaves will become damaged more or less, even though the insects be destroyed;

still, it prevents any great damage, and insects thus poisoned are out of the way for good, both as regards future damage by the individual and by its otherwise possible offspring.

When the idea of poisoning the tobacco leaf was first suggested it met with considerable opposition. It was feared that the persistence of the poison might render the tobacco dangerous to the human consumer. This fear still exists in many quarters; in fact, the average smoker, and, still more, the average chewer, would hardly fancy the



FIG. 4.—Northern tobacco worm, or "horn worm" (*Protoparce celeus*): a, adult moth; b, full-grown larva; c, pupa—natural size (original).

idea that his tobacco had, at any time, been treated with arsenic. The same feeling, however, existed when Paris green was first used on the potato crop for the Colorado potato beetle. It was expressed when fruit growers began to spray apple trees for the codling moth, and it still remains in regard to the use of arsenicals upon cabbages, in spite of the fact that most cabbage growers are using them, and that it has been repeatedly shown that the quantity of poison which is effective is so infinitesimally small that not the least possible harm can result to the consumer. The same holds with regard to tobacco.

Careful experimentation by Professor Garman in Kentucky and the experience of practical tobacco growers in Kentucky and South Carolina have shown that, properly used, no possible harm can result from the application of an arsenical poison. Summarizing from the practical experience on record, it is the opinion of the writer that Paris green, in the proportion of 1 pound to 125 gallons of water, is the proper mixture to apply to tobacco plants. Used at this strength, it will not kill all of the flea-beetles, but it will greatly reduce their numbers. It will also be efficacious at this strength against the young caterpillars of the horn worm, or hornblower, and against sun-

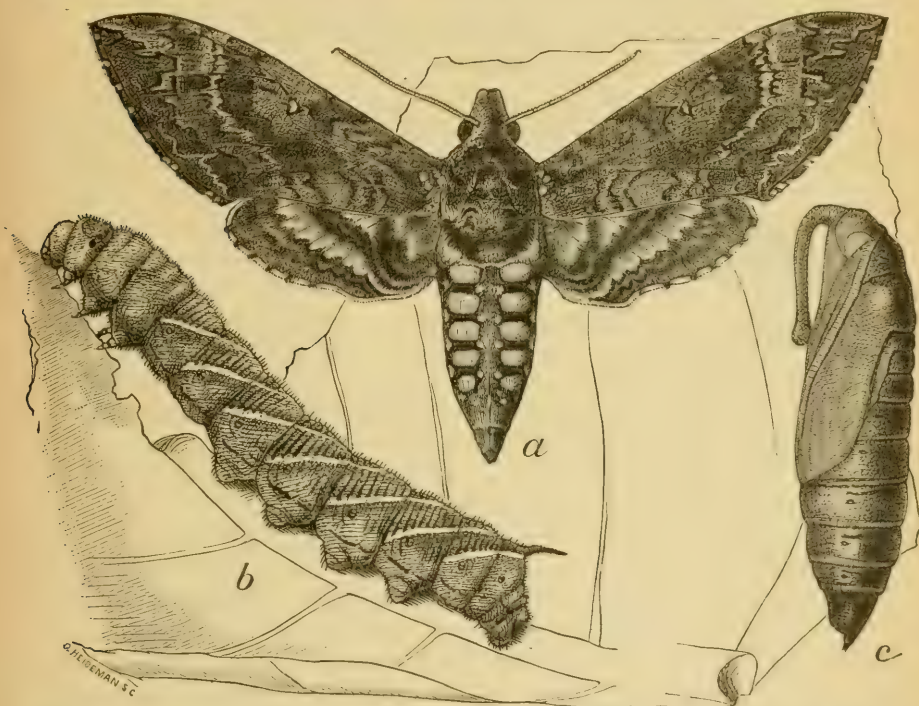


FIG. 5.—Southern tobacco worm (*Protoparce carolina*): a, adult moth; b, full-grown larva; c, pupa—natural size (original).

dry other tobacco insects, as will later be shown. In the dry state, it may be mixed with twenty parts of spoiled flour or any fine dust, such as road dust, and dusted on the plants from one of the machines known as powder guns, or from a coarse cloth bag or sack.

After the available portions of the plants are cut in the fall, and the planter is ready to plow his fields to small grain or some other crop, there will be a positive advantage in treating the portions of the plants left in the field with a considerably stronger arsenical mixture. This, in the warm days of autumn, will kill the insects remaining in the fields, many of which would otherwise have successfully hibernated and put in an appearance ready for destructive work the

following season. The writer was particularly struck with this point the first week in November in southern Virginia. The tobacco crop had been entirely harvested, but no killing frosts had occurred. The days were warm and sunny and the nights cold. On the remaining portions of the tobacco plants in the fields were many flea-beetles, bud worms, and cutworms, which, a week or so later, would have entered hibernating quarters. Just at this time, with a slight expenditure of energy, the useless remnants of the tobacco plants could have been poisoned, and practically all of these insects destroyed, much to the advantage of next year's crop.

THE TOBACCO HORN WORMS, OR HORNBLLOWERS.

(*Protoparce carolina* Linn. and *Protoparce celeus* Hübn.)

There are two species of large sphinx moths whose larvæ, or caterpillars, eat the leaves of tobacco, tomato, and allied plants, including, occasionally, the Irish potato. These caterpillars, from the fact



FIG. 6.—Southern tobacco worm dead and shriveled from bacterial disease—natural size (original).

that each bears upon one of the posterior segments of its body a rather stout, curved horn, have become popularly known as horn worms. This term "horn worm" has, in some incom-

prehensible way, been corrupted into "hornblower" in Maryland and Virginia, where it is applied to the adult moth.

Tobacco growers do not distinguish between the two different kinds of horn worms, and for practical purposes it is not in the least necessary that they should distinguish them. As a matter of general interest, however, it may be stated that the horn on the end of the body of *carolina* is red, while that of *celeus* is black. Both are green in color, with oblique white stripes on the sides of the body. These white stripes extend farther up on the back with the caterpillar of *carolina* than they do with the caterpillar of *celeus*. The curious brown pupa into which the caterpillar transforms, which is found under the surface of the ground, and which is at once recognized by the handle-shaped process which issues from the top of the head, is distinguished in the two species by the fact that the handle-shaped process, which is really the tongue case, is much longer with the pupa of *celeus* than it is with the pupa of *carolina*.¹ From these pupæ, or chrysalids, issue the adult moths. The moths of the two species may be distinguished from the fact that *carolina* is darker, and the orange spots along the sides of the body are more vivid, while the center of the hind wings of *celeus* bears two distinct, zigzag lines, which in *carolina* become blurred, darkened, and indistinct. All of these points are plainly brought out in figs. 4 and 5.

¹ The figures of both Harris and Glover are misleading on this point.

Both of these insects occur more or less abundantly in the tobacco fields over the entire tobacco-growing regions of the United States. In certain localities one species will be much more abundant than the other, and in other localities the numbers will be more evenly divided. In general, it may be said that *celeus* is the more northern species, and is found more abundantly in the more northern tobacco fields, while farther south *carolina* is apt to be much the more common. In the tobacco-growing regions of Connecticut, for example, according to Professor Fernald, *celeus* is the more common tobacco worm, while in Florida the reverse condition holds. Both species occur from Canada to Florida, and as the region of tobacco culture fails in the North, both species feed upon tomato. *Carolina* extends its range into the West Indies and South America, but *celeus* is not found south of Florida.

The life histories of both species are practically identical. Varying in date, according to the climate, the moths make their appearance, working their way out of the underground pupæ, or chrysalids, from May 1 well on into June, pair, and lay their eggs singly on the undersides of the leaves. The young caterpillars hatch from these eggs, which, by the way, are laid in the dusk of the evening, in from four to eight days, according to Professor Alwood's observation of *carolina*. In the course of their growth they cast their skin four times, and in less than a month become full grown, burrow into the soil, and transform to pupæ.

The number of generations in a year varies in different localities. In the greater part of the tobacco-growing region planters have recognized that there are two "crops" of the worms. This holds in portions of Maryland. At Blacksburg, Va., Professor Alwood has found that one "crop" is normal, and that there are occasional indications of a second "crop," or generation. In Florida, where the moths make their appearance early in May, according to Professor Quaintance, the first generation of caterpillars is not particularly destructive, but the second generation, which appears during July, causes the most damage. A third generation is normal, and probably a fourth, although in July caterpillars of various sizes may be found in the fields at one time. The retardation of development in some individuals, and acceleration in others, bring about an intermingling of generations, which is always marked in insects in the South where the number of generations exceeds three. In Cuba, where the *carolina* horn worm is said to be a severe pest to the tobacco industry, there is probably an even larger number of generations.

Actual damage done by horn worms varies greatly in different seasons. Frequently, for a number of years, they will not be too abundant to be kept down readily by hand picking, and then will come a season in which they are so numerous that it is very difficult to save the crop without incurring a prohibitive expense. Again,

comparative immunity during one summer will be followed by considerable damage the next. Professor Garman, in Bulletin No. 66 of the Kentucky Agricultural Experiment Station, states that the summer of 1896 was one of extraordinary abundance. The horn worms "were present on both tobacco and tomato in myriads, and proved so destructive that some fields of tobacco were abandoned and in the fall presented only a wilderness of stems and midribs of leaves. In such fields as many as five worms, representing both species, were frequently observed on a single plant. Their advent was so sudden that before the seriousness of the outbreak was realized tobacco that had been the pride of the owner and showed scarcely a mutilated leaf was severely injured. It was near cutting time when they became most abundant, and some growers preferred to cut their tobacco as the best means of saving it. On suckers in fields and on abandoned tobacco the worms remained until frosts killed the plants. Large numbers of both species were collected in October from such tobacco, and they were observed in fields until October 12."

Both kinds of horn worms are extremely subject to disease and to the attacks of natural enemies. Caterpillars which are observed to turn dark in color are attacked by a bacterial disease, which invariably results in their death (fig. 6). Certain parasitic insects attack others, and all tobacco growers are familiar with the appearance of a horn worm partly or entirely covered with little, white, oval cocoons. Such specimens should not be crushed, since the cocoons are made by one of the most important of the parasites of these larvæ, which, if allowed to emerge undisturbed, will increase the mortality among the caterpillars. Others may occasionally be noticed bearing very minute, oval, white eggs sticking closely to the skin. These are the eggs of a *Tachina* fly, and the maggots which hatch from these eggs bore into the caterpillar and eventually destroy it.

REMEDIES.

It will be unnecessary to repeat what has been said under the head of "The tobacco flea-beetle" concerning the use of arsenical poisons. When the first generation of horn worms appears (and each tobacco grower must determine the approximate date from observation in his own fields), an application of Paris green, either dry or in the liquid form, as elsewhere described, is by far the best remedy when the insects are numerous. In ordinary seasons and in certain localities the tobacco crop will not suffer so severely that it can not be protected by the ordinary process of hand picking, or "worming," as it is called. Most conservative tobacco planters send their hands through the fields to pick off the caterpillars and crush them, and rely upon no other remedial work.

The adult moth possesses a long beak, through which it sucks the nectar of flowers, being attracted especially to the sweetest flowers

and those possessing a long, tubular corolla, like the honeysuckle and the morning-glory and the flower of the Jamestown, or "jimson" weed. Many years ago it occurred to an observing planter that the jimson-weed flowers might be poisoned to advantage, and from this suggestion has grown up the custom in certain parts of the country of squirting into the flowers of the jimson weeds growing in the immediate vicinity of the tobacco fields a certain amount of sweetened water poisoned with cobalt or "fly stone." A modification of this process, described by Professor Quaintance, is as follows: "In the evening a quantity of the bloom of the jimson weed is procured and is placed promiscuously through the field under holes in horizontal slats, supported by sticks or otherwise, and into the flowers is placed, by means of a quill, a small quantity of this poisoned mixture. This poison should be of about the following proportions: Cobalt, one ounce; molasses or honey, one-fourth pint; water, one pint." This practice is so well understood among tobacco growers that it is hardly worth detailed mention, except to state that experiments at the Louisiana experiment station and elsewhere have proved that it is effective as a palliative. At the experiment station just mentioned jimson weed was grown for this purpose, and the writer remembers a doleful complaint by the director of this station some years ago to the effect that his farming visitors interfered with the experiment, since their horror of weeds was so great that, in passing through his grounds, they pulled up the jimson weeds and spoiled his experiment.

Many years ago Townend Glover, the first entomologist of the Department, in mentioning this method of catching the moths of the horn worm, suggested the manufacture of artificial porcelain or tin jimson flowers, which would be perennial in the highest degree and could be poisoned year after year. The writer is not informed, however, as to whether this suggestion has ever been followed.

A sweetened preparation, poisoned with arsenic, however, has been tried in Maryland by Prof. W. G. Johnson. The material was placed in wooden pails, perforated near the bottom and set in granite pans, into which the poisonous liquid was leached. These traps or decoys were set upon stakes about the field a little higher than the tops of the tobacco. Although the experiment appeared to be successful, Professor Johnson reserves his final conclusions until he has had an opportunity to make further tests another year.

Most tobacco growers have learned by experience the necessity of carefully removing the worms from the leaves after or during cutting and before they are carried into the barn, since otherwise they will continue to feed in the barn on the drying leaves. Where such care has not been exercised, the evaporation of bisulphide of carbon in the barn, in accordance with the directions and with the precautions which will be described under the head of remedies for the cigarette beetle,

will kill the worms before they can do further damage, and the quality of the tobacco, as we have proved by experiment, will not be injured in the least, the reverse being the case when the smoke from a damp wood fire is used, as it is sometimes for this purpose.

THE BUD WORMS.

(*Heliothis rhexia* S. & A. and *Heliothis armiger* Hübn.)

Just as there are two distinct though very similar insects known as horn worms, so there are also two distinct and rather similar insects known as bud worms, which occur frequently together in the same field and work in a somewhat similar

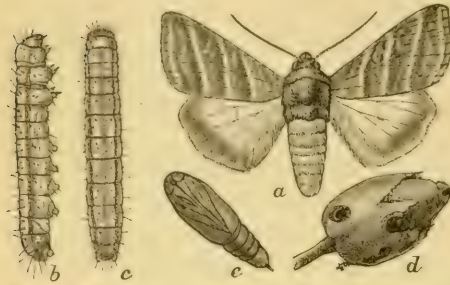


FIG. 7. The true bud worm (*Heliothis rhexia*): a, adult moth; b, full-grown larva, from side; c, same, from above; d, seed pod bored into by larva; e, pupa—natural size (original).

manner. We shall take the liberty of distinguishing between them by calling one the true bud worm and the other the false bud worm.

The true bud worm (*Heliothis rhexia*) occurs in the more southern portions of the tobacco-growing regions, but has not been noted in tobacco fields north of Maryland. The adult insect is a small, greenish moth, well illustrated in fig. 7. The larva or caterpillar of this moth, also characteristically shown in fig. 7, is nearly always found in the bud of the tobacco plant about the time the plant is ready to top. In some seasons they occur in large numbers and damage the tobacco considerably. In the early part of the season, as a general thing, but few of them are found, and in ordinary seasons they are not especially noticed during the early "worming" of the tobacco. In August they begin to be more abundant, and generally leave the plant about the end of the month, entering the ground, transforming to pupæ and issuing as moths toward the end of September. These dates are Virginia

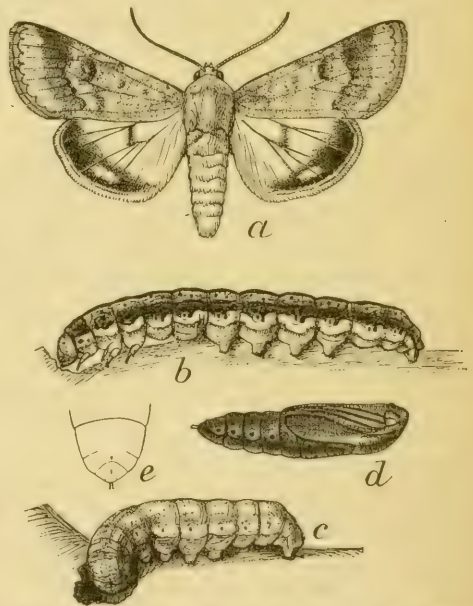


FIG. 8.—False bud worm or cotton boll worm (*Heliothis armiger*): a, adult moth; b, dark full-grown larva; c, light-colored full-grown larva; d, pupa—natural size (original).

dates, but hold reasonably well as far south as Mississippi. As just stated, the greatest damage done by this insect is by the August brood, when it enters the rolled-up leaves or bud of the plant. In September and October the next generation of caterpillars is found boring into the seed pod and occasionally into the flower stem. We have received the insect at various dates from July 10 to the end of August from Virginia, Georgia, Alabama, and Mississippi. The worst account of damage which has come to us was re-

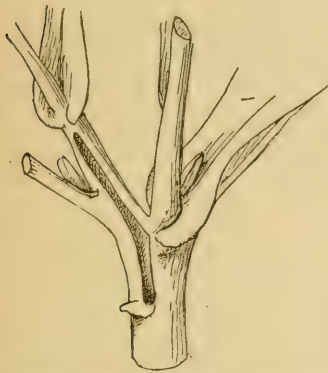


FIG. 10.—Work of young false bud worm—reduced (original).

ceived in July, 1888, from Mr. J. S. Barnwell, of Darien, Ga., who said that in general this bud worm damaged his tobacco more than the horn worm. When

young it occurred abundantly in the buds and ate so many holes through the young leaves as to render them unfit for wrappers.

The caterpillars of the last fall genera-

tion enter the ground and hibernate as pupæ. The insect has several other food plants aside from cotton, but its most abundant food in the South is the weed known as ground cherry (*Physalis viscosa*). It has been found on several solanaceous weeds, as well as upon cultivated geranium.

The species which we have called the false bud worm (fig. 8) is the same caterpillar which, when occurring upon cotton, is called the "cotton boll worm;" upon tomato, the "tomato fruit worm," and upon corn, the "corn-ear worm." It is the larva of *Heliothis armiger*, a cosmopolitan species of varied food habits, and which, as its different popular names denote, has a destructive propensity for boring into anything like a pod. Fortunately, tobacco is not a preferred



FIG. 9.—Work of full-grown false bud worm in flower stem—reduced (original.)



FIG. 11.—Work of false bud worm in seed pods—reduced (original).

food plant. The insect lives on corn until the ears are too hard for easy attack, and then transfers its attention to other plants. From this it results that it is usually only late in the season that the larvæ are found upon tobacco. Here it works much as does the true bud worm, boring into the seed pods and into the flower stalks, as indicated in figs. 9, 10, and 11, and also, more rarely, feeding upon the leaves. These remarks hold for Virginia. In Florida, however, according to Mr. Quaintance, the principal damage is done by these caterpillars during the early part of the year, when they do not have corn or cotton to feed upon. The eggs are deposited in the bud, and the larvæ do very serious harm by feeding on the young and as yet unfolded leaves. A large worm may quite devour a bud. In color and markings the false bud worm is one of the most variable of caterpillars. On tobacco the writer has found specimens of a uniform, light green color, without spot or stripe, and others the general effect of which was nearly black. Between these two extremes many variations occur. This insect, like the true bud worm, passes the winter in the pupa condition under the surface of the ground.

REMEDIES.

The arsenical spray recommended for the flea-beetle and for the horn worms will also be efficacious, to a certain degree, against the bud worms, but in Florida Mr. Quaintance has found it desirable to make a specific treatment for these insects, which, when they are very numerous, may be advisable, although it necessitates considerable trouble. He recommends sprinkling poisoned corn meal in the bud. He adds a half teaspoonful of Paris green to a quart of finely-ground corn meal, which is thoroughly mixed by stirring. He then makes a sprinkler of a baking-powder can, in the bottom of which numerous holes have been punched, so that when it is shaken the poisoned corn meal may be peppered over the bud. He advises that the poison should be frequently applied, and after heavy rains.

With these, as with other tobacco insects, there is much to be gained by clean culture, in keeping down the weeds on which the insects feed, and also by careful attention to corn and tomatoes which may be growing in the vicinity. Late fall plowing is efficacious against both species by breaking up the little earthen cells in which the pupæ are found under the ground, thus exposing them to the action of frosts.

THE NEW TOBACCO BUG, OR "SUCK-FLY."

(*Dicyphus minimus* Uhler.)

This insect is not only new as a tobacco enemy but is new to science, and was named and described by Professor Uhler in November, 1898. The specimens from which the description is drawn were received at the office of the Entomologist from Florida, but Professor Uhler had previously received specimens from Louisiana, Texas, Mississippi, and Alabama, with an account from the latter State that it feeds upon

tomatoes. It was first brought to the writer's attention in July, 1898, by Mr. T. A. Carroll, of Gainesville, Fla. Specimens which were received at that time were fed here upon tobacco through the remainder of the season. The eggs have not been found, but two generations developed between July and the killing frosts, on which date the bugs disappeared, hiding away in the full-grown condition for hibernation. The different stages of growth observed are shown in fig. 12. The species has been studied to better advantage in the field by Mr. Quaintance in Florida, who considers it a serious enemy of the crop,

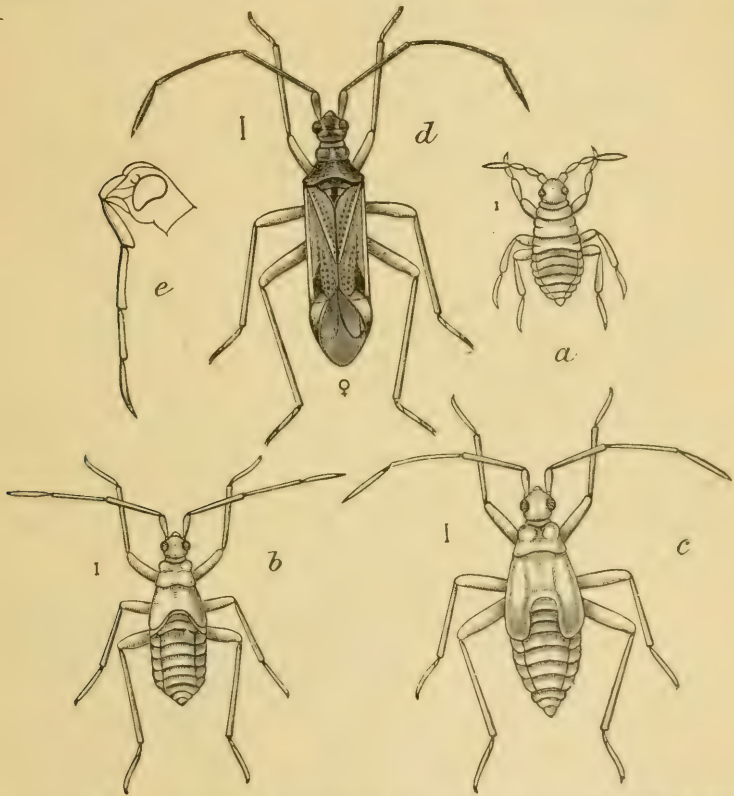


FIG 12.—The "suck-fly" (*Dicypthus minimus*): a, newly hatched; b, second stage; c, nymph; d, adult; e, head and beak from side—enlarged (original).

and states that it has been known to growers in Columbia County for the past ten years. The first crop is generally not damaged to any serious extent, but the second crop and late tobacco are frequently quite destroyed. Mr. Quaintance also states that the insects make their appearance in injurious numbers during the first and second weeks in June, and that the full-grown bugs are first noticed in some restricted portion of the field, as on the plants in one corner, from which they gradually move over the field. They have been observed on neglected tobacco as late as November 22.

The insects damage the leaf by sucking the cell sap through their beaks. The infested leaf soon becomes yellowish in color and somewhat wilted, and the older leaves eventually split in places, so that they become very ragged. The immature specimens of the bug live on the underside of the leaves, but the adults live both above and below. The full-grown specimens are partial to shade, and may be observed feeding close to the margin of a shade thrown by an overhanging leaf. Experienced tobacco growers say that leaves which have been badly infested with the "suck-fly" are very difficult, if not impossible, to properly cure. Mr. Quaintance says that the eggs are deposited singly in the tissues of the leaf, and mainly in the smaller veinlets. He finds that the egg state lasts about four days, and that in Florida the entire life cycle of a given generation is only about fifteen days. He was unable to keep the adult insect alive in a breeding cage for more than six days, but we have kept them in Washington City for at least a month.

REMEDIES.

This, again, is an insect against which clean culture will be reasonably effective. A thorough cleaning up of the fields and burning of the trash in the autumn are measures which should be adopted when the insect is abundant. Actual test experiments with different insecticides were made by Mr. Quaintance, who found that a concentrated solution of nicotine, diluted with sixty parts of water, will kill a large proportion of the full-grown insects and many of the young. He advises that this spray be applied early in the morning, as at that time the insects are less active. Early set trap plants will probably be an advantage in concentrating the hibernating insects, so that they can be readily killed.

OTHER SUCKING BUGS.

Several true bugs, which damage the leaves by inserting their beaks and sucking the juices, causing a shriveling or drying of the leaf in the same way as the harlequin cabbage bug injures the leaves of the cabbage, are found in the tobacco fields. Several of these plant bugs are known indifferently to tobacco planters as "stink bugs," on account of the disagreeable odor which they give out. We have never known any of them to be a very serious factor in tobacco growing.

One of the commonest of these bugs in the more northern portions of the cotton belt is *Parcilocystus diffusus* Uhler. This insect is found in all seasons of the year, and when very abundant the remedies recommended against the "suck-fly" may be used. The writer has found it very abundant and in all stages of growth in Virginia tobacco fields as late as November.

Another species is a green bug shown at fig. 13, and which is known scientifically as *Euschistus variolarius*. This is a species which was

found by Professor Garman wilting plants in an experimental plat of tobacco at the Kentucky Agricultural Experiment Station in the summer of 1896, and which is suspected to have done more or less damage over quite a wide extent of country that season.

An interesting little bug of the family Scutelleridæ, viz, *Corimelaena extensa* Uhl., has been found damaging native tobacco at Cedar Ranch, Ariz., by Prof. C. H. T. Townsend. It is reported to be the only

member of its family which lives upon tobacco, and as Professor Townsend found it to be very abundant, it is probably an important future enemy to the tobacco crop, especially if tobacco culture increases in the Southwest.

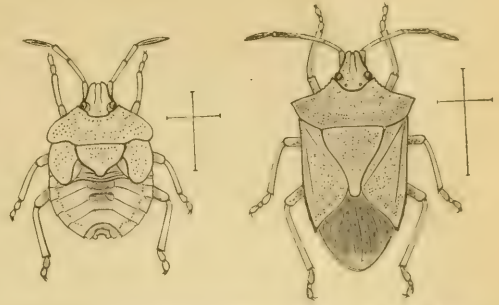


FIG. 13.—*Euschistus variolarius*: nymph at left; adult at right—enlarged (original).

THE TOBACCO LEAF-MINER, OR "SPLIT WORM."

(*Gelechia solanella** Boisd.)

This insect, which is also comparatively new in this country as a tobacco insect, was first brought to the writer's attention as an enemy to this plant early in 1896 by Prof. Gerald McCarthy, formerly of the North Carolina experiment station. The adult insect is a minute, grayish moth, shown in fig. 14. Its eggs are laid upon the leaves,

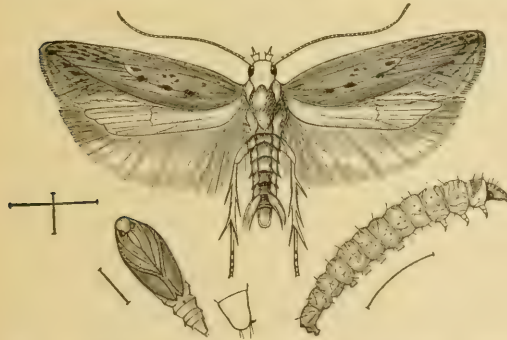


FIG. 14.—Tobacco split worm: adult moth above; larva below at right; pupa below at left, with side view of enlarged anal segment—all enlarged (original).

and the minute caterpillar bores between the surfaces of the leaf, making a flat mine, often of considerable size, with a gray discoloration visible from both sides of the leaf. Frequently there is a distortion when the mine occurs near a large vein, as shown in fig. 15. There are two or more generations in the course of the summer, and the insect is

more noticeable in the autumn than at an earlier date. Down to the year 1898 the insect was known to occur as a tobacco insect in this country in North Carolina only, the exact locality not having been given to us by Professor McCarthy, nor did he mention it in the little account of the insect which was published in Bulletin No. 141, of the North

* Since the publication of the original article this insect has been found to be Zeller's *Gelechia operculella*, the type having been received from Texas.

Carolina Agricultural Experiment Station. During that year, however, Mr. Quaintance found the insect damaging tobacco in many localities in Florida, and the writer discovered it mining tobacco leaves in Pittsylvania County, Va. Specimens were also received from Mr. J. J. Wolfe, of Sandy Run, Lexington County, S. C., who stated that he was troubled the same season by this insect, which made its appearance early and increased its damage as the season

advanced. The writer of this bulletin is indebted to Mr. Wolfe for the characteristic name of "split worm," by which he stated the insect was commonly known in his vicinity. He also stated that during that year it did more damage in his neighborhood than all other insects combined.

When Professor McCarthy first sent this insect to the Entomologist for identification, there was found to be some difficulty in ascertaining just what it was. On consulting a specialist in the group of insects to which this one belongs, it was decided to be *Gelechia piscipellis* of Zeller, an insect which has been reared in this country from the common horse nettle or ball nettle (*Solanum carolinense*), and under this name it was treated in the North Carolina bulletin by Mr. McCarthy, and in the Florida bulletin by Mr. Quaintance. A more careful study was given to the insect, however, during the preparation of this paper, and a great similarity was noticed between it and an insect which has been known as the potato tuber moth, an article on which was published in *Insect Life* (Vol. IV, p. 239 to 242), and which, after being recorded as damaging the tubers of the Irish potato in Algeria, Australia, and New Zealand, made its appearance in portions of California, also working in potato tubers; in fact, the only difference noted in the series reared from potato tubers from California and from tobacco leaves in North Carolina was a general difference in size. On comparison of the larvæ and pupæ from the two food plants these also



FIG. 1.—Work of split worm—reduced(original).

were found to be identical.

To settle the matter beyond all question, a series of the moths from potato and tobacco were sent to Lord Walsingham, the English authority on the insects of this group, who confirmed our surmise as to their identity; and the tobacco leaf-miner must now be known as *Gelechia solanella* Boisduval. It transpires also that the same insect has been observed injuring tobacco in New South Wales "by burrowing

within the stems and larger branches;"¹ that it also occurs in tobacco in Algeria, and that it has also been described under the different name (*Gelechia tabacella* Ragonot) as injuring tobacco in Algeria. In this country it has also been observed by Professor McCarthy as mining in the leaves of horse nettle (*Solanum carolinense*) on the margins of tobacco fields, and is recorded by Mr. Quaintance as mining in the leaves of tomato and in the leaves and boring into the fruit of the eggplant. We have, therefore, as its food plants, potato, tobacco, horse nettle, tomato, and eggplant; and as its localities, eastern Australia, New Zealand, Algeria, California, Colorado, Florida, South Carolina, North Carolina, and Virginia.

In Florida the leaf-miners make their appearance about the last of May, and are said to occur as late as October. There are several generations each year. In southern Virginia the writer found full-grown larvæ in the lower leaves of tobacco plants about the margins of the fields as late as November 2. The insect was not known to tobacco growers in that vicinity, and when one prominent and exceptionally well-informed tobacco planter was shown these leaf blotches he said: "That is not the work of an insect, but is what we call 'wet weather rot,'" and appeared surprised when the writer pulled apart the two surfaces of the leaf and showed him the little worm. At that season of the year the little mining caterpillar was something over a quarter of an inch in length and of a dull greenish color, with darker head and thorax.

REMEDIES.

Professor Quaintance has shown that in Florida this leaf-miner, when feeding, does not pass its entire life in one place, but after eating for awhile it will gnaw to the outside, and then crawling around over the leaf, will finally enter the tissue again in a new place. From this habit of the insect, it at once becomes evident that it will be subject to destruction by an arsenical spray, just as are the caterpillars which uniformly feed externally upon the leaves. Moreover, from the fact that in Virginia and North Carolina it is frequently well on into July before the tobacco crop is planted out, the early generation of the insect must be passed in some other food plant. Where horse nettles are present in the vicinity of the fields the insects will feed in the leaves of this plant, and the second generation will attack the tobacco fields. The destruction of all horse nettles, then, about June 1, will be a practical measure which will reduce the numbers of the split worms in tobacco to a minimum.

Although this insect has not been found in the nightshade and the jimson weed, it is altogether likely that it will also attack these weeds, and their destruction, therefore, is equally to be recommended.

The insect doubtless passes the winter in the leaves as a larva or a pupa, and the advisability of destroying old, blotched leaves which

¹ A. S. Olliff, Agr. Gaz., N. S. W., September, 1892.

have no value is at once evident. Clean culture in this direction is advisable on other grounds, and is certainly desirable as a means of reducing the numbers of this species.

The partial synonymy furnished to the writer by Lord Walsingham is as follows:

Solanella, Bdv.

Gelechia terrella,¹ Wkr. Cat. Lp. Ins. B. M., XXX, 1024 (1864). *Bryotropha solanella* Bdv., J. B. Soc. Cent. Hort. 1874; Rag. Bull. Soc. Ent. Fr. 1875. XXXV-XXXVII. *Gelechia tabacella*, Rag. Bull. Soc. Ent. Fr. 1879, CXLVI-CXLVII. *Gelechia solanella*, Meyr. Pr. Lin. Soc. N. S. W., 112 (1879); N. Z. Jr. Sc., II, 590 (1885). *Lita tabacella*, Rag. Bull. Soc. Ent. Fr. 1885, CXI-CXII. *Gelechia solanella*, Meyr. Tr. N. Z. Inst., XVIII, 166-7 (1886). *Lita solanella* (Olliff), Agr. Gaz. N. S. W., II, 158-9 (1891).

CUTWORMS.

Tobacco is no less subject to the attacks of cutworms than are many other crops. Grown in seed beds, as it is, and set out in newly plowed fields in the summer, the plants are naturally attacked by the hungry worms, which for some days at least had existed in the soil deprived of food. It is a common experience with tobacco growers, as well

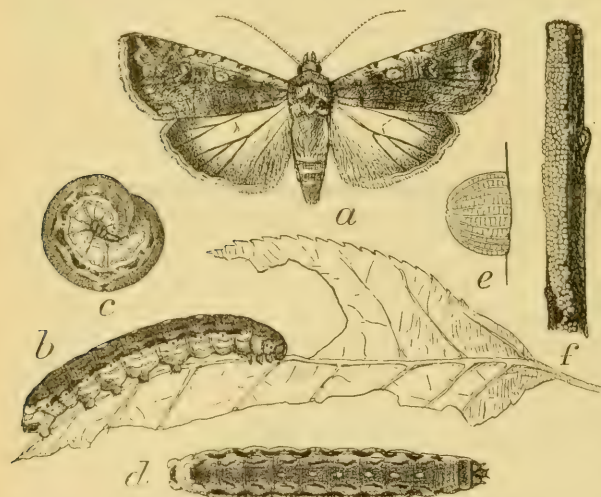


FIG. 16.—*Peridromia saucia*: a, adult; b, c, d, full-grown larvæ; e, f, eggs—all natural size except e, which is greatly enlarged (original).

as other agriculturists, that cutworms are always more numerous in fields left in fallow for a period before being planted to certain crops. There is a greater variety of vegetation in such fields, and the moths which lay the eggs which produce the cutworms are more apt to be attracted. Tobacco growers who have planted their fields to clover after the removal of the tobacco crop are also apt to find that there are plenty of cutworms present the following season. Those who plant winter grain, however, find that the following crop is less liable to damage by cutworms. This indicates the relative value of different cropping methods. It is a comparatively simple matter, however, to rid a field of cutworms before planting out the tobacco, and as a measure of safety this course may be followed to advantage. After the field is

¹ Oldest name but a homonym.

plowed and is bare of vegetation and ready for planting, if the tobacco grower will thoroughly spray a patch of grass or weeds with Paris green and water, and will then cut it and drop it in little bunches here and there throughout the tobacco field, he will find that the cutworms in the soil, in the absence of other food, will eat this cut poisoned vegetation and will be destroyed, so that the tobacco plants can be set out without fear of damage.

Without such preventive treatment (and especially when, as indicated above, the land has grown up with weeds, grass, and other wild vegetation) before the planting out of the tobacco crop, the result will frequently be the cutting down by the cutworms of a large proportion of the tobacco plants; and the writer has known of instances where more than one-half of the crop had to be replanted.

Some farmers, instead of a poisoned trap of green vegetation, prefer the so-called bran-arsenic mash, which originally came into use as a remedy against insects in California, where it was successfully used against the California devastating grasshopper. It was first tried against cutworms in California also successfully. In the East it has been used against cutworms affecting different crops, and with the greatest success in southern

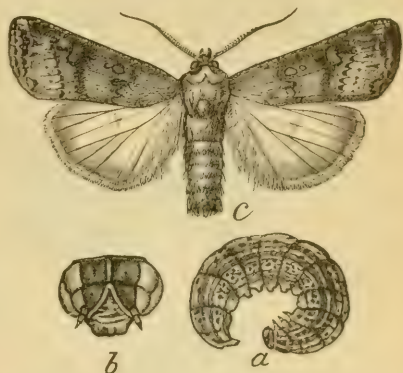


FIG. 17.—*Agrotis ypsilon*, one of the tobacco cutworms: a, larva; b, head of same; c, adult—natural size (original).

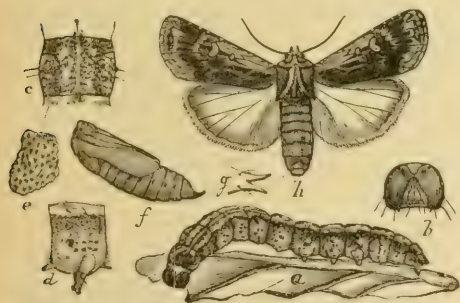


FIG. 18.—*Agrotis annexa*: a, larva; f, pupa; h, adult—natural size (h, original; others from Ann. Rept. U. S. Dept. Agr., 1894).

Virginia against the American locust or grasshopper. In the tobacco field it has also been successfully used against cutworms in Florida. The bait, or mash, is prepared by thoroughly mixing Paris green and bran at the rate of 1 pound of Paris green to 50 or 75 pounds of bran. Just before using, it should be moistened slightly with water and sweetened with molasses. The Florida custom is to put a

small ring of the poisoned mixture around each newly set plant, or to place a teaspoonful at two or three different places. Cutworms prefer this poisoned mash even to green vegetation. It should be renewed frequently, and fowls or live stock should not be allowed access to it. Mr. Quaintance recommends that where seed beds are

badly infested with cutworms the poisoned bran should be drilled along in various parts of the bed where it will be readily accessible to them. The bran-arsenic mash produces the best results when it is used as we have recommended for the poisoned-vegetation trap to rid the land of cutworms before the tobacco plants are transferred from seed bed to field. In this case the land is prepared beforehand, and a little of the mash is dropped in the drill near the place where the plant will be set. Prof. W. G. Johnson recommends that

this should be done from three to five days before the plants are set out.

A number of different species of cutworms may be concerned in this damage, and some of the characteristic forms which have actually been found in the tobacco field are illustrated in figs. 16, 17, and 18.

OTHER TOBACCO LEAF-FEEDERS.

Several insects of less economic importance than those which we have already mentioned are occasionally found feeding upon the leaves of the plant.



FIG. 19. The cabbage *Plusia*: a, moth; b, full-grown larva; c, pupa, with its cocoon—natural size (original).

The so-called cabbage *Plusia* (*Plusia brassicae* Riley).—This insect (fig. 19), which occurs in most parts of the United States and has a number of different food plants, has been found in tobacco fields in Maryland, feeding upon the leaves, by Mr. F. C. Pratt, of the Division of Entomology, although not in sufficient numbers to give it a high rank as a tobacco insect. It is one of the species which is readily destroyed by the arsenical spray.

Mamestra legitima Grote.—This insect (fig. 20), which is allied to the cutworms, feeds exposed upon the foliage of different plants. Its larva is a very handsome caterpillar, bright yellow in color, with velvety-black longitudinal lines. It has never been recorded as a tobacco insect, but was found rather abundantly by the writer in tobacco fields in southern Virginia upon the leaves, which, in some cases, were badly ragged. This insect can also be easily destroyed by the arsenical spray.

The tobacco thrips (*Thrips tabaci* Lindeman).—This minute insect, which sometimes does considerable damage to onions and which has been popularly known in this country as the "onion thrips," was originally described, in 1888, by Professor Lindeman, of Russia, as an

enemy of tobacco in Bessarabia. It occurs upon many plants in this country, but has never been found upon tobacco, although in southern Russia it at one time caused much damage to the leaves, puncturing them and causing them to wilt. As this insect, occurring in this country as it does from the Atlantic to the Pacific, may at any time be found upon tobacco, it is worthy of mention and of an illustration in this connection. It is shown at fig. 21.

The "white fly" of tobacco (*Aleyrodes tabaci* Gennadius).—One of the insects especially noticeable in Europe is a minute form which looks like a small scale insect on the under side of the leaf. Its damage to tobacco in Greece was demonstrated by Professor Gennadius in 1889. A closely allied or identical species occurs upon tomato in this country, but European specimens from tobacco have not been compared with our tomato species, so that we can not speak positively as to their identity. The tomato species is, however, liable to be found upon tobacco.

Tree crickets (*Oecanthus fasciatus*).—Young tree crickets are occasionally found upon tobacco, eating the leaves to some slight extent. They do no especial damage, but are worth mentioning in this connection. The greatest damage done by tree crickets is occasioned by the punctures in the stems of plants like raspberry and blackberry, which are made by the females in laying their eggs. So far as known, they have not been observed to puncture tobacco for this purpose.

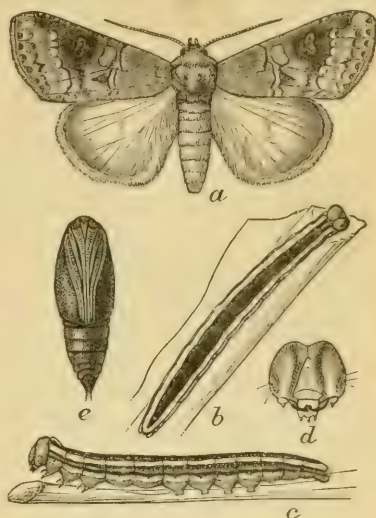


FIG. 20.—*Mamestra legitima*: a, adult; b, larva from above; c, same from side; d, head of same from front; e, pupa—all natural size except d, which is enlarged (original).

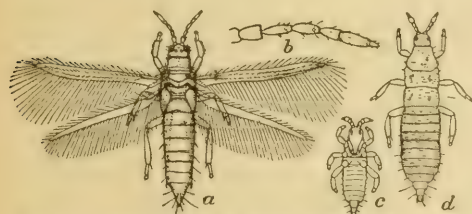


FIG. 21.—*Thrips tabaci*: a, adult; b, antenna of same; c, young larva; d, full grown larva—enlarged (original).

In portions of Maryland these little insects are known as "chatteracks," presumably from the song of the male.

The mealy bug (*Dactylopius citri* Risso).—In the course of greenhouse observations on tobacco plants at Washington City it has been found that the common mealy bug thrives and multiplies alarm-

ingly upon tobacco plants. Since this mealy bug is an outdoor pest of many plants in the South, it seems from this experience that it has

only to be brought into the immediate vicinity of a tobacco field to spread upon the crop, and under favorable conditions it may occasionally do considerable damage.

Plant lice.—Several species of plant lice are known in Europe to occur occasionally upon tobacco, and several of our American species which affect solanaceous plants are liable at any time to be found upon tobacco. As a matter of fact, however, we have never known any especial damage to be done to tobacco by these insects. Late in the autumn of the present year the terminal leaves of the tobacco plants growing in the experimental plats of the Division of Entomology became covered with a plant louse known as *Nectarophora tabaci* Pergande. This species has been found by its describer, Mr. Pergande, of the Division, during the last two years upon the leaves of young pear trees on the grounds of the Department of Agriculture, and also upon the leaves of apple, Rumex, Leucanthemum, and Forsythia, as well as tomato and egg-plant. During the summer of 1898 the same species was received from Dr. F. P. Phelps, of Mount Holly, Md., with the information that 5 acres of tomato plants were covered with countless millions of these lice. The writer would not be at all

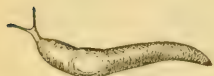


FIG. 22.—*Limax campestris*—natural size (after Binney).

surprised if in the near future considerable damage to tobacco by this species should be reported.

The twelve-spotted Diabrotica, or "corn root-worm" (*Diabrotica 12-punctata*).—In Kentucky, according to Professor Garman, this small, greenish beetle, marked with twelve black spots, which is so common on cucumbers, squashes, melons, and other cucurbitaceous plants, is often found on tobacco leaves, eating small round holes. Its larvae feed on the roots of corn, and the beetle is only a casual visitor of the tobacco field. It can not be considered a dangerous insect by the tobacco grower.

Slugs (*Limax campestris* Binney, and allied species).—Damage is occasionally done to young tobacco plants in seed beds by slugs. Specimens were received last summer from Dr. H. T. Fernald, the State zoologist of Pennsylvania, which he said had very seriously damaged some of the tobacco beds by eating the young leaves. These specimens were submitted to Dr. W. H. Dall, of the Smithsonian Institution, who said that they were young and badly contracted, but probably belonged to the species known as *Limax campestris* Binney, which is shown by fig. 22.

THE CIGARETTE BEETLE.

(*Lasioderma serricorne* Fabr.)

Of the insects injurious to cured tobacco none approach, in economic importance, the species which has become known as the cigarette beetle. The name "cigarette beetle" is more or less of a misnomer, since the insect not only feeds in all kinds of dried tobacco, and even in snuff, but also in many other substances, such as rhubarb, ginger,

cayenne pepper, ergot, turmeric, yeast cakes, rice, figs, prepared fish food, and dried plants prepared for the herbarium.

Working as it does in all kinds of cured tobacco and living in this substance during all stages of its existence, it damages cigarettes and cigars principally by boring out of them, making round holes in the wrappers so that they will not draw (fig. 23). Leaf tobacco is injured for wrapping purposes by being punctured with holes made both by the larvæ and the beetles, and fillers and fine cut are injured by the reduction of their substance by the actual amount consumed by the larvæ. The adulteration of fine cut by the bodies of the insects and by their excrement is also a kind of damage, though an entomological acquaintance of the writer insists that he buys infested short cut by preference, both because he can get it cheaper and because the bodies of the insects impart a distinct and not disagreeable flavor to the tobacco. He admits, however, that it is a cultivated taste.

The cigarette beetle is practically cosmopolitan, and probably occurs in most tobacco factories in the Southern States, as well as in most wholesale drug stores. In the far South this insect multiplies rapidly throughout the greater part of the year, and its development is practically continuous in artificially warmed factories farther north. Observations upon the life history of the species were made by Prof. George F. Atkinson some years ago, when he was connected with the North Carolina Agricultural Experiment Station, and more recently by Mr. Chittenden, of the Division of Entomology. It seems tolerably certain that there are two generations produced each year in the District of Columbia. Professor Atkinson says that he has seen the beetles in copulation in January at Chapel Hill, N. C., but Mr. Chittenden has never seen the beetles later than November or earlier than May. It passes the coldest of the winter months in the larva state. In artificially warmed buildings the insect is apt to be present in all stages at almost any time of the year. Professor Atkinson observed that the larvæ hatch in eleven days from the time of egg laying, and that they remain as larvæ from sixty to seventy days. The larva (fig. 24) when full grown spins a fairly compact cocoon of a silky substance covered with bits of whatever substance the insect is breeding in. In this cocoon it soon transforms to a pupa and the adult beetles emerge

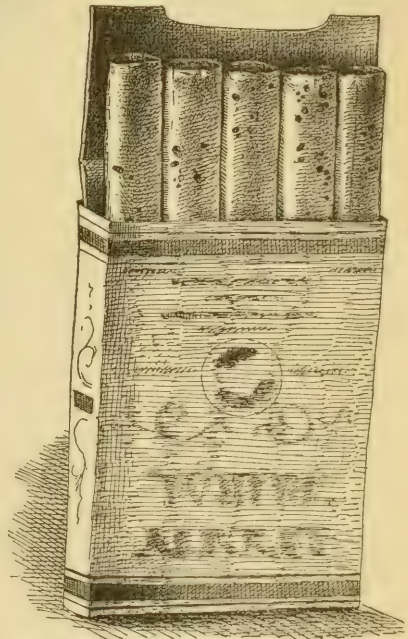


FIG. 23.—Work of cigarette beetle—reduced one third (original).

later. Mr. Chittenden has found that in a warm room the entire life round may be undergone in forty-seven days. These insects were reared in a dry yeast cake, however, and not in tobacco.

It is only within comparatively recent years that the cigarette beetle has become at all serious to tobacco manufacturers in this country,

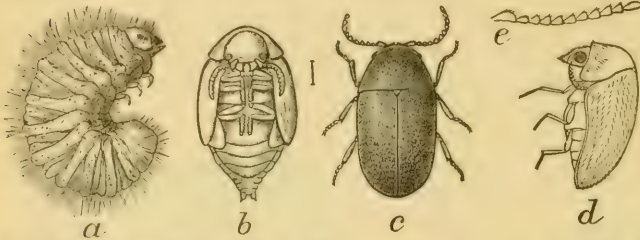


FIG. 24.—The cigarette beetle: *a*, larva; *b*, pupa; *c*, adult; *d*, side view of adult; *e*, antenna—all greatly enlarged, *e* still more enlarged (re-engraved from Chittenden's illustration).

but it has been increasing and spreading of late, and at the present time it is found not only in many factories, but also in warehouses, tobacco barns, and retail establish-

ments. The writer knows of one little shop into which it was accidentally introduced in some plug tobacco. It increased, entered the show cases, and ruined a large number of high-priced cigars and cigarettes. The shopkeeper was in despair, but finally, at the advice of the writer, submitted his entire stock to fumigation with bisulphide of carbon, and thus completely rid his establishment of the beetle.

REMEDIES.

With a small establishment like the one just mentioned, it is a comparatively simple matter to destroy the insect by means of the fumes of bisulphide of carbon. The place was clean and well-swept and dusted, and all that was necessary was to have a tight case (a show case was used) and the entire stock of tobaccos, cigarettes, and cigars was placed in the case in installments, and a saucerful of bisulphide of carbon was evaporated over night. In the morning the contents of the case were removed, the store was aired, and the next night another lot was fumigated. For some time after this experience the shopkeeper in question used the same case as a quarantine box, and put all of the tobacco which he bought through the fumigating process before he placed it on his shelves. Gradually, however, his vigilance was relaxed, and he has since had no experience with the cigarette beetle.

In a large factory, however, the case is, of course, very complicated. The average factory is not a clean place. It is frequently an old building, roughly built, with innumerable cracks in the floors and walls, which, in the course of years, have become filled with tobacco dust and fragments. Even the crevices about the windows are filled with comminuted tobacco. Frequently large stocks of tobacco are kept on hand a long time. When the cigarette beetle has once obtained a foothold in such an establishment, it is a matter of considerable time, expense, and energy to get rid of it, and at the same time it is as much as the reputation of such a factory is worth to allow goods to go out containing any specimens of the insect in any form.

There is an unfortunate and, the writer believes, wholly unjustified prejudice against steaming tobacco. Experiments carried on by Professor Atkinson in 1885 or 1886 showed that proper steaming will destroy this insect in all of its different stages, and the practical experience of several tobacco manufacturers, whose establishments have been visited by the writer, has indicated the same thing. With this knowledge, therefore, barring prejudice, there is no reason why a tobacco manufacturer should ever put out any infested tobacco. It becomes important, however, to entirely rid his establishment of the insect, and here nothing but heroic measures will avail. Taking a room at a time, the floor and walls must be thoroughly cleaned, the walls whitewashed, and all beams and floor cracks subjected either to steaming or to a thorough spraying with kerosene or benzine, great care being taken to avoid fire in case the latter substance is used. Benzine is preferable to kerosene on account of its greater volatility, in that the establishment can be more readily rid of the odor, but it is more dangerous on account of its higher inflammability. The beetles are quite inclined to fly to the light and to settle about the windows; therefore the window cracks should be especially looked after. With such a thorough treatment as this, taking room after room, the writer feels sure that the insect can be exterminated in almost any tobacco factory.

Where it is not desired to use steam, experience has shown that, as above indicated, bisulphide of carbon may be used to good advantage. With leaf tobacco such a fumigation must be very thorough to kill the insects embedded in the mass of the leaves. Experiments made in the writer's office with hydrocyanic-acid gas show that it is not to be compared in efficiency with bisulphide of carbon for this work. While the bisulphide treatment is preferably made in a tight bin, it may also be carried on in a tight room. In either case 1 ounce of the liquid should be evaporated for every $62\frac{1}{2}$ cubic feet of space, or 1 pound for every 1,000 cubic feet. Every precaution should be taken, however, to see that the room is perfectly tight, and also that no fire is allowed to enter the room until after it has been most thoroughly aired. The vapor of bisulphide of carbon in confinement is inflammable and explosive.

In cigar and cigarette factories much that we have just said will be applicable. The tobacco, before use, should be steamed, if possible. Loose tobacco should not be left exposed at night. Boxes or piles of cigarettes or cigars, after being made, should be covered very tightly to prevent the access of the beetles. These precautions are more important during May and late August and September than at other times of the year, since at these periods the adult insects are flying about in great numbers. This statement holds for Virginia and Maryland, but for Key West and other Southern points the dates will have to be altered.

As a matter of interest, it may be said that there is a little four-winged fly which is parasitic on the cigarette beetle, laying its eggs in the larva of the beetle. This parasite is known scientifically as *Catolaccus anthonomi* Ashmead, and has been found in several

tobacco factories. It is doubtful, however, whether by its work it will ever rid an establishment of the beetle, but it undoubtedly helps to prevent rapid multiplication, and consequent great damage.

OTHER INSECTS INJURING DRIED TOBACCO.

There are several beetles which occasionally affect tobacco after the leaves are dried, in much the same manner as does the cigarette beetle, but none of them, as we have said, approximate in importance the latter insect. The so-called drug-store beetle (*Sitodrepa panicea*, fig. 25), an insect which has an enormous range of food, and occurs upon very many articles found on the shelves of drug stores, whence its popular name, will also breed successfully in tobacco, although we can not say that this substance is its preferred food. No cases have been brought to our attention of any serious damage to tobacco by this species. The ordinary rice weevil (*Calandra oryza*), another insect which feeds upon various stored products, has also been found breeding in tobacco, although its importance as a tobacco insect does

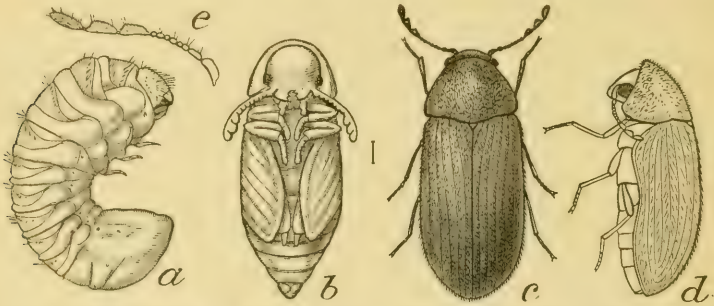


FIG. 25.—The drug-store beetle: a, larva; b, pupa; c, adult; d, adult from side; e, antenna—all greatly enlarged, e still more enlarged (reengraved from Chittenden's illustration).

not exceed that of the drug-store beetle, if indeed it equals it. Another insect which, though not at all a tobacco insect, became, some years ago, the cause of a curious litigation regarding the rejection of a large cargo of tobacco from this country by the French Government, is the so-called leather beetle (*Dermestes vulpinus*). The tobacco in question, in numerous hogsheads, was received in France, and upon examination it was found to have been perforated by numbers of the larvæ of this latter beetle, which had burrowed into the tobacco for a considerable distance and transformed to pupæ and later into beetles. The entire cargo was rejected by the French Government and returned to America, and the litigation which ensued was through the endeavor to place the responsibility for the entrance of the insect upon either the shippers or the carriers. It was shown that the tobacco must, at some period of its journey, have been stored in close proximity to bales of hides affected by this insect. The larva of the *Dermestes*, instinctively on reaching full growth, crawls away from its original habitat and bores into any near-by substance to find a protected spot for pupation. In this case the larvæ were

attracted by the cracks in the tobacco hogsheads, and not deterred by the pungent character of the contents of the hogsheads, they bored their way in, searching for a secure place to transform.

FOREIGN TOBACCO INSECTS WHICH HAVE NOT YET REACHED THE UNITED STATES.

In a previous paragraph we have mentioned incidentally the little scale-like insect known as *Aleyrodes tabaci* as one which has probably not made its appearance in American tobacco fields. Professor Targioni-Tozzetti, the Italian writer, to whose work reference is made in the first page of this paper, has listed 144 species of insects found in tobacco fields of Europe and adjoining countries, the great majority of which, however, are not important enemies of this crop and most of which are never likely to be brought to this country. There are in south Europe several distinctive cutworms which injure the crop in the same way as do allied forms in the United States; several grasshoppers, which feed upon the leaves of the plant, and several caterpillars which do occasionally more or less damage in the same way as do the leaf-feeding caterpillars which we have incidentally mentioned. In south Russia (Bessarabia) there is a tenebrionid beetle (*Opatrum intermedium*) which injures tobacco by attacking the stems underground. There are several plant bugs, several species of plant lice, wireworms, and other forms of greater or less importance which are recorded by the writer, but, on the whole, probably none of them are worthy of extended mention in this bulletin.

CONCLUSIONS.

REMEDIES IN GENERAL.

Upon looking over the whole ground, it seems to the writer that the tobacco crop is not a difficult one to protect from insects. It has not so many insect enemies as many other important crops, and the method of cropping is itself unfavorable to the increase of insects and favorable to their ready treatment. This is especially true of all portions of the country north of Florida.

In the seed beds there is in general no great danger of insect damage, but if insects should obtain a foothold most of them can be readily and safely treated by means of the arsenical spray.

After the plowing of a field into which plants are to be set attention should be paid to ridding the soil of cutworms. This can be done safely and easily by means of the poison-trap crop or the bran-arsenic mash mentioned in detail under the head "Cutworms." Where either of these remedies is used it is really a matter of indifference from the insect standpoint whether the land has been left fallow or whether clover or small grain has been grown. The planter can really follow just which course he thinks is best for his land without reference to cutworms, whereas without this treatment, as previously stated, fallow land or land planted to clover is apt to be full of worms, and the tobacco crop will have to be in part replanted.

At this time, or preferably earlier, it is important that the solanaceous weeds in the immediate vicinity of the field, and particularly the nightshade (*Solanum nigrum*), the horse nettle or bull nettle (*Solanum carolinense*), and the jimson weed (*Datura stramonium*), should be cut down, with the exception of a few marked clumps. These clumps will act as traps for nearly all of the tobacco insects. Practically all of the tobacco insects in the vicinity will be attracted to them and can be readily and economically treated with heavy doses of Paris green for the leaf-feeding species and with a spray of kerosene and water for the sucking bugs. Large numbers of these insects can be easily killed in this way, greatly to the protection of the young tobacco plants when they are set out.

During the growing season of the plants in the field there can be no doubt of the availability and usefulness of the arsenical spray. When used with reasonable care there can be no possible danger, as has been shown by careful experimental work and by chemical analysis of sprayed plants. Poison distributors, both for dry and liquid poison, are on the market, and the process is not an expensive one. It is used already by many practical growers, and it seems to the writer that the man who does not adopt it in time of necessity is behind the times.

After the crop has been cut the stubs of the plants and many leaves will be left. Moreover, in a warm autumn there will be considerable suckering. All of the tobacco insects left in the field which can by any possibility reach this sparse remaining tobacco vegetation will do so. Most of the horn worms, it is true, have gone into the ground and transformed into pupæ, but cutworms, budworms, leaf-feeding caterpillars, the last generation of split worms, all of the sucking bugs and the flea-beetles, during the warm, sunny, autumn days which precede the first killing frost will rely upon these remaining leaves and suckers for food. This is apt to be just the time when the tobacco planter pays no attention to the insect question, since his crop is gathered, but it is nevertheless just the time when he has his tobacco insects more or less concentrated, and upon worthless vegetation, which he can treat with heavy doses of arsenical poisons or even with pure kerosene without fear of loss. There can be no doubt that a little insecticide work at this time of the year will so greatly reduce the number of the insect enemies of the crop that the benefit will be felt in a marked degree the following season. The expense of such treatment would be very slight. A single individual in a day could cover a very large field.

Two of the points just mentioned, namely, the use of solanaceous weeds as traps in the spring and the treatment of mutilated plants and suckers in the fall, have not previously been mentioned in any article upon tobacco insects as far as the writer is aware. He believes that both suggestions are eminently practical, and that by their adoption an enterprising tobacco planter can reduce insect damage to a minimum.

DIV. INSECTS.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 127.

IMPORTANT INSECTICIDES:

DIRECTIONS FOR THEIR PREPARATION AND USE.

[A Revision of Farmers' Bulletin No. 19.]

BY

C. L. MARLATT, M. S.,
FIRST ASSISTANT ENTOMOLOGIST.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1901.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., February 6, 1901.

SIR: I have the honor to transmit herewith copy for a Farmers' Bulletin on insecticides. This bulletin will supplant Farmers' Bulletin, No. 19, prepared in 1894, under my direction, by Mr. C. L. Marlatt, first assistant entomologist. The latter publication has gone through four slightly revised editions, but has now been thoroughly revised and in large part rewritten by Mr. Marlatt, and considerable new matter has been added. I therefore recommend that it be reissued under a new number, to take the place of the older publication. The constant call for information on insecticides warrants the prompt publication of this bulletin in a large edition.

Respectfully,

L. O. HOWARD,
Entomologist.

HON. JAMES WILSON,
Secretary of Agriculture.

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IMPORTANT INSECTICIDES: DIRECTIONS FOR THEIR PREPARATION AND USE.

INTRODUCTORY.

Without going minutely into the field of remedies and preventives for insect depredators, it is proposed to give in this bulletin brief directions concerning a few of the insecticide agents having the widest range and attended with the greatest usefulness, economy, and ease of application. These are not covered by patent, and in general it is true that the patented articles are inferior, and many of the better of them are in fact merely more or less close imitations of the standard substances and compounds hereinafter described. Only such brief references to food and other habits of the insects covered will be included as are necessary to illustrate the principles underlying the use of the several insecticide agents recommended.

RELATION OF FOOD HABITS TO REMEDIES.

For the intelligent and practical employment of insecticides it is necessary to comprehend the nature and method of injury commonly due to insects. Omitting for the present purpose the many special cases of injury which necessitate peculiar methods of treatment, the great mass of the harm to growing plants from the attacks of insects falls under two principal heads based on distinct principles of food economy of insects, viz, whether they are biting (mandibulate) or sucking (haustellate), each group involving a special system of treatment.

INJURY FROM BITING INSECTS.

The biting or gnawing insects are those which actually masticate and swallow some portion of the solid substance of the plant, as the wood, bark, leaves, flowers, or fruit. They include the majority of the injurious larvæ, many beetles, and the locusts. (See fig. 1.)

For these insects direct poisons, such as the arsenicals, which may be safely applied to the leaves or other parts of the plant attacked,

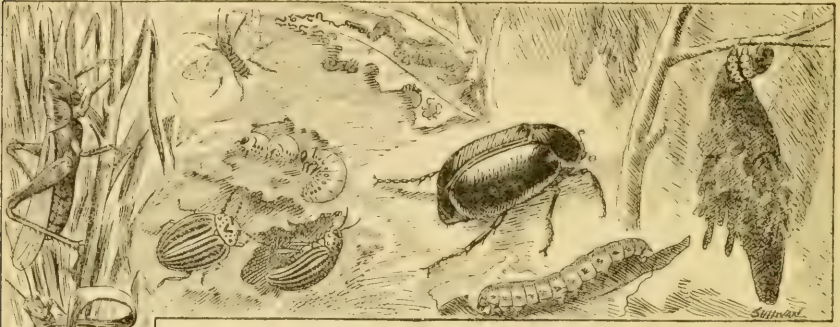


FIG. 1.—Illustrating the different classes of biting insects, all natural size (original).

and which will be swallowed by the insect with its food, furnish the surest and simplest remedy, and should always be employed, except where the parts treated are themselves to be shortly used for the food of other animals or of man.

INJURY FROM SUCKING INSECTS.

The sucking insects are those which injure plants by the gradual extraction of the juices, either from the bark, leaves, or fruit, and include the plant-bugs, plant-lice, scale insects, thrips, and plant-feeding mites. These insects possess, instead of biting jaws, sucking beaks or bristles, which are thrust down through the outer layers of the bark

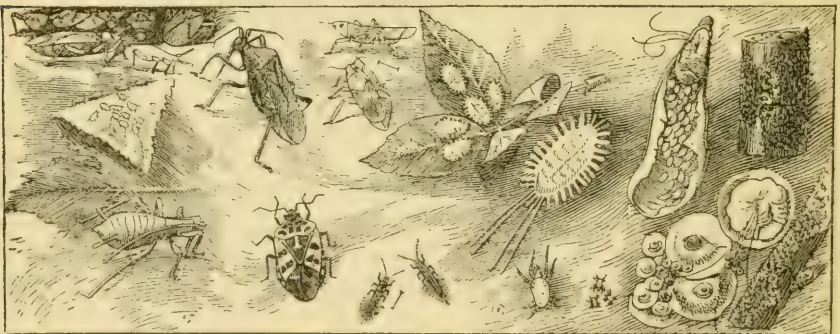


FIG. 2.—Illustrating the different classes of sucking insects, natural size and enlarged (original).

or leaves into the soft, succulent tissues beneath and used to extract the plant juices, with a resulting injury not so noticeable as in the first group, but not less serious. (See fig. 2.)

For this class of insects the application of poisons, which penetrate little, if at all, into the plant cells, is of trifling value, and it is neces-

sary to use substances which will act externally on the bodies of these insects, either as a caustic or to smother or stifle them by closing their breathing pores, or to fill the air about them with poisonous fumes. Of value also as repellants are various deterrent or obnoxious substances.

Wherever it is not desirable to use poisons for biting insects, some of the means just enumerated will often be available.

GROUPS SUBJECT TO SPECIAL TREATMENT.

The general grouping outlined above relates to the species which live and feed upon the exterior of plants for some portion or all of their lives, and includes the great majority of the injurious species. Certain insects, however, owing to peculiarities of habit, inaccessibility, or other causes, require special methods of treatment. Of these, two groups properly come within the scope of this bulletin: (1) Those working beneath the soil, or subterranean insects, such as the white grubs, root maggots, root-lice, etc., and (2) insects affecting stored products, as various grain and flour pests.

Three other groups, which include species requiring very diverse methods of treatment, and therefore not coming within the limits of this bulletin, are (1) the internal feeders, such as wood, bark, and stem borers, leaf-miners, gall insects, and species living within fruits; (2) household pests, and (3) animal parasites.

The classification of insects outlined above, based on mode of nourishment and indicating groups amenable to similar remedial treatment, simply stated, is as follows:

- I. External feeders:
 - (a) Biting insects.
 - (b) Sucking insects.
- II. Internal feeders.
- III. Subterranean insects.
- IV. Insects affecting stored products.
- V. Household pests.
- VI. Animal parasites.

INSECTICIDES FOR EXTERNAL BITING INSECTS (FOOD POISONS).

THE ARSENICALS: PARIS GREEN, SCHEEL'S GREEN, ARSENATE OF LEAD, AND LONDON PURPLE.

The arsenical compounds have supplanted, practically, all other substances for the insects falling under this heading.¹ The two arsenicals in most common use, and obtainable everywhere, are Paris green and London purple. The other two arsenicals mentioned, viz. Scheele's

¹ *Hellebore*.—The powdered roots of the white hellebore (*Veratrum viride*) are often recommended and used as an insecticide, particularly as a substitute for the arsenites. This substance is useful when a few plants only are to be sprayed, as in yards and

green and arsenate of lead, are less known and not so easily obtainable, but in some respects are better than the first-mentioned poisons, as will be shown later. The use of powdered white arsenic is not recommended, on account of its great liability to scald foliage, as well as for the fact that it is apt to be mistaken for harmless substances. The arsenicals mentioned have the following characteristics:

Paris green is a definite chemical compound of arsenic, copper, and acetic acid (known as the aceto-arsenite of copper), and should have a nearly uniform composition. It is a rather coarse powder, or, more properly speaking, crystal, and settles rapidly in water, which is its greatest fault. Its excessive cost, about 20 cents a pound, is due to its being crystallized with acetic acid, making it a more brilliant pigment, but giving it a coarse grain and rendering it a much poorer insecticide.

Scheele's green is similar to Paris green in color, and differs from it only in lacking acetic acid; in other words, it is a simple arsenite of copper. It is a much finer powder than Paris green, and therefore more easily kept in suspension, and has the additional advantage of costing only about half as much per pound. When properly washed and prepared by the manufacturers it is less harmful to foliage even than Paris green, is quicker in effect, and should supplant the latter as an insecticide. It is used in the same way and at about the same strength as Paris green and London purple.

London purple is a waste product in the manufacture of aniline dyes and contains a number of substances, chief of which are arsenic and lime. It is quite variable in the amount of arsenic and is not so effective as the green poisons and is much more apt to scald unless mixed with lime. It comes as a very fine powder, and is more easily kept in suspension than Paris green. It costs about 10 cents a pound.

Arsenate of lead is prepared by combining, approximately, 3 parts of the arsenate of soda with 7 parts of the acetate of lead (white sugar of lead) in water. These substances when pulverized unite readily and form a white precipitate, which is more easily kept suspended in water than any of the other poisons. Bought wholesale, the crystallized acetate of lead costs about $7\frac{1}{4}$ cents a pound (or the uncrystallized brown sugar of lead, 5 cents), and the arsenate of soda 5 cents a pound.

small gardens, but is too expensive for large operations. It kills insects in the same way as the arsenicals, as an internal poison, and is less dangerous to man and the higher animals; but if sufficient be taken it will cause death. It is particularly effective against the larvæ of sawflies, such as the cherry slug, rose slug, currant worms, and strawberry worms.

It may be applied as a dry powder, preferably diluted with from 5 to 10 parts of flour, and dusted on the plants through a muslin bag or with powder bellows. The application should be made in the evening, when the plants are moist with dew. Used as a wet application, it should be mixed with water in the proportion of 1 ounce to the gallon of water and applied as a spray.

It is now on the market as a dry powder, white or colored with a dye, ready for immediate use, costing about 10 cents a pound, and also in paste form. Arsenate of lead may be used at any strength from 3 to 15 pounds to the 100 gallons of water without injury to the foliage, and in this respect is much safer on delicate plants than any other arsenical. Its use is advised where excessive strengths are desirable or with delicate plants where scalding is otherwise liable to result. With this insecticide there is an advantage in using the freshly prepared and wet mixture in that it gives a more filmy and adhering coating to foliage, the same fineness not being secured when it has been dried and repulverized.

In point of solubility and corresponding danger of scalding the foliage these arsenicals fall in the following order, the least soluble first: Arsenate of lead, Scheele's green, Paris green, and London purple. The difference between the first three is not great in the particulars noted nor also in point of effectiveness against larvæ or other insects. London purple is ordinarily considerably less effective.

HOW TO APPLY ARSENICALS.

There are three principal methods of applying arsenicals. The wet method, which consists in using these poisons in water in the form of spray, is the standard means, secures uniform results at least expense, and is the only practical method of protecting fruit and shade trees. The dry application of these poisons in the form of a powder, which is dusted over plants, is more popular as a means against the cotton worm in the South, where the rapidity of treatment possible by this method, and its cheapness, give it a value against this insect, in the practical treatment of which prompt and economical action are the essentials. This method is also feasible for any low-growing crop, such as the potato, young cabbages, or other plants not to be immediately employed as food. The third method consists in the use of the arsenicals in the form of poisoned baits, and is particularly available for such insects as cutworms, wireworms, and locusts in local invasions.

The wet method.—Either Scheele's green, Paris green, or London purple may be used at the rate of 1 pound to 100 to 250 gallons of water, or 1 ounce to 6 to 15 gallons. The stronger mixtures are for such vigorous foliage as that of the potato for the Colorado potato-beetle, and the greater dilutions for the more tender foliage of the peach or plum. An average of 1 pound to 150 gallons of water is a good strength for general purposes. The poison should be first made into a thin paste in a small quantity of water and quicklime added in amount equal to the poison used to take up the free arsenic and remove or lessen the danger of scalding. An excess of lime will do no injury. The poisons thus mixed should be strained into the spray

tank or reservoir, care being taken that all the poison is pulverized and washed through the meshes of the strainer. The use of the lime is especially desirable in the case of the peach and plum, the foliage of which, particularly the former, is very tender and easily scalded. To the stronger foliage of the apple and most shade trees Paris green may be applied without danger at the strength of 1 pound to 150 gallons of water; with London purple it is always better to use the lime.

The arsenate of lead is prepared by carefully pulverizing and combining, in a small quantity of water, the weight of the two ingredients needed at the strength decided upon as indicated by the capacity of the spray tank. The chemical combination is effected in a few minutes and the resulting milky mixture is ready for the tank. Lime is not needed with this arsenical.

If it be desirable to apply a fungicide at the same time, as on the apple for the codling moth and the apple scab fungus, the Bordeaux mixture¹ may be used instead of water, adding the arsenical to it at the same rate per gallon as when water is used. The lime in this fungicide neutralizes any excess of free arsenic and makes it an excellent medium for the arsenical, removing, as it does, all liability of scalding the foliage and enabling an application of the arsenical, if necessary, eight or ten times as strong as it could be employed with water alone.

The arsenicals cannot be safely used with most other fungicides, such as the sulphate of copper, eau celeste or iron chloride solution, the scalding effects of these being greatly intensified in the mixture.

The dry method.—The following description applies to the pole-and-bag duster commonly used against the cotton worm: A pole 5 to 8 feet long and about 2 inches in diameter is taken, and a three-fourths inch hole bored through it within six inches of each end. Near each end is securely tacked a bag of "8-ounce osnaburg cloth," 1 foot wide and

¹*Bordeaux mixture formula.*—Into a 50-gallon barrel pour 30 gallons of water, and suspend in it six pounds of bluestone in coarse sacking. Slack 4 pounds of fresh lime in another vessel, adding water slowly to obtain a creamy liquid, free from grit. When the bluestone is dissolved add the lime milk slowly with water enough to fill the barrel, stirring constantly.

With insufficient lime the mixture sometimes injures the foliage, and it should be tested with a solution obtained by dissolving an ounce of yellow prussiate of potash (potassium ferrocyanide) in one-half pint of water. If there be insufficient lime in the Bordeaux mixture the addition of a drop or two of this solution will cause a brownish-red color, and more lime should be added until no change takes place when the solution is dropped in. Use the Bordeaux mixture promptly, as it deteriorates on standing.

Stock solutions of both the bluestone and lime may be kept for any length of time. Make the stock bluestone by dissolving in water at the rate of 2 pounds to the gallon. The stock lime is slacked and kept as a thick paste. Cover both mixtures, to prevent evaporation and keep the lime moist. For the 50-gallon formula add 3 gallons of the bluestone solution to 50 gallons of water, and introduce the stock lime slowly until there is no reaction with the testing solution.—GALLOWAY.

18 inches to 2 feet long, so that the powdered poison may be introduced into the bags with a funnel through the holes at the ends of the pole. The bags are filled with undiluted Paris green, which is generally preferred to London purple on account of its quicker action, and the apparatus is carried on horse or mule back, through the cotton fields, dusting two or four rows at once. The shaking induced by the motion of the animal going at a brisk walk or at a trot is sufficient to dust the plants thoroughly, or the pole may be jarred by hand. The application is preferably made in early morning or late evening, when the dew is on, to cause the poison to adhere better to the foliage.

From 1 to 2 pounds are required to the acre, and from 10 to 20 acres are covered in a day. The occurrence of heavy rains may necessitate a second application, but frequently one will suffice. This simple apparatus, on account of its effectiveness and cheapness, is employed throughout the cotton belt to the general exclusion of more complicated and expensive machinery. The cost frequently does not exceed 25 cents per acre, and the results are so satisfactory that the leaf worm is no longer considered a serious factor in cotton culture.

With the patented air-blast machines for the dry distribution of poisons, arsenicals are diluted with 10 parts of flour, lime, or ground gypsum, and from 60 to 75 acres may be covered in a day by using relays of men and teams. Greater uniformity is secured with these machines in distribution of the poisons, but their cost (from \$30 to \$60) prevents their general use.

The planter should have a good supply of poison on hand and apparatus for its application prepared in advance, since when the worm puts in an appearance its progress is very rapid, and a delay of a single day may result in material damage to the crop.

If small garden patches are dusted with poison by this or similar means from bags or with hand bellows, it is advisable always to dilute the poison with 10 parts of flour, or preferably lime, and for application to vegetables which will ultimately be used for food, as the cabbage, 1 ounce of the poison should be mixed with 6 pounds of flour or 10 of lime and dusted merely enough to show evenly over the surface. Arsenicals should not be applied to lettuce or other vegetables the free leafage of which is eaten.

As poisoned bait.—It is not always advisable or effective to apply arsenicals directly to the plants, and this is particularly true in the case of the attacks of the grasshopper and of the various cutworms and wireworms. In such cases the use of poisoned bait has proved very satisfactory.

For locusts, take 1 part, by weight, of white arsenic, 1 of sugar, and 6 of bran, to which add water to make a wet mash. Place a tablespoonful of this at the base of each tree or vine, or apply a line of baits just ahead of the advancing army of grasshoppers, placing a

tablespoonful of the mash every 6 or 8 feet, and following up with another line behind the first.

Bran and Paris green, on the authority of Prof. J. B. Smith, thoroughly mixed and sprinkled dry on cabbage heads proved a most successful remedy for cabbage worms, the latter preferring the poisoned bran to the cabbage, to their prompt undoing. The same dry mixture has been successfully employed against cutworms and is recommended by Smith for the army worm, running it in rows 10 feet apart across the infested field.

For sow bugs, or pill bugs, which frequently are injurious pests to tender flowering plants and vegetables grown under frames or in glass houses, poisoned slices of potato have proven the most effectual remedy. The freshly sliced potato may be poisoned by dipping in a strong arsenical solution, or by dusting thickly with a dry arsenical, and distributed over the beds. Pansy beds have been notably protected in this way, and a Michigan vegetable grower reports that in two nights he destroyed upward of 24,000 of these bugs by this means in four houses used for lettuce growing.

Another remedy for baiting cutworms and also for wireworms is to distribute poisoned green, succulent vegetation, such as freshly cut clover, in small bunches about in the infested fields. Dip the bait in a very strong arsenical solution, and protect from drying by covering with boards or stones. Renew the bait as often as it becomes dry, or every three to five days. The bran-arsenic bait, as above mentioned, will also answer for cutworms.

TIME TO SPRAY FOR BITING INSECTS.

For the codling moth the apple and pear should receive the first application as soon as the blossoms fall, which is also the time for the second treatment of the scab fungus; the second spraying should be given one week later and before the calyx closes and the fruit turns down on the stem.

The reason for this course arises from the fact that the parent moth comes out in the spring, about the time the blossoms are falling from the apple trees, and glues her eggs on the skin of the young fruit and on the adjacent leaves also. The larvæ, hatching in about a week, crawl about until they find lodgment in the blossom end of the young apples, and before entering the fruit take several meals in the partial concealment formed by the calyx, and doubtless also nibble more or less of the foliage before they reach the apple, if the eggs happen to be deposited on the leaves. During several days, therefore, the little apple worms feed externally, and the object of spraying is to insure their being poisoned by thoroughly coating the leaves, and especially the calyx end of every fruit, with the arsenical mixture. By the time the calyx closes most of the larvæ will have entered it and will be so

protected by the folding in of the leaves of the calyx that they will be beyond the reach of any poison later applied. In the northern portion of the United States, where the codling moth is single-brooded, this early treatment is all that is necessary. With the exception, however, of rather limited districts, as, for example, northern New York and New England, the codling moth is double, or more numerous, brooded, and spraying must be kept up until late in the season or until the fruit is half or two-thirds grown, and in such regions also the arsenical poisoning must be supplemented with the old banding system. A great many of the common leaf-feeding enemies of apple trees are destroyed by the arsenical treatment for the codling moth.

For the curculio of the stone fruits—plum, cherry, peach, etc.—two or three applications should be made; the first as soon as the foliage is well started, the second at the time of the exposure of the young fruit by the falling of the calyx, and perhaps a third a week later, particularly if rains have intervened after the last treatment. The poison here acts to destroy the parent curculio instead of the young larvæ, which, hatching from eggs placed beneath the skin of the fruit, are not affected by the poison on the outside. The adult curculio, however, as soon as it comes from its hibernation, feeds on the bloom and foliage, and later on the young fruit also, and is destroyed by the arsenical before its eggs are deposited.

For leaf-feeding insects in general, such as the Colorado potato beetle, blister beetles, elm leaf-beetle, maple worm, etc., the application should be made at the earliest indication of injury and repeated as often as necessary.

Fruit trees should never be sprayed when in bloom, on account of the liability of poisoning honeybees or other insects useful as cross fertilizers.

CARE IN USE OF ARSENICALS.

It must be remembered that these arsenicals are very poisonous and should be so labeled. If ordinary precautions are taken, there is no danger to man or team attending their application. The wetting of any, which can not always be avoided, is not at all dangerous, on account of the great dilution of the mixture, and no ill effects whatever have resulted from this source. With some individuals the arsenate of lead, when in strong mixture, affects the eyes, but this is unusual and, with a little care in spraying, the mist need not strike the operator at all.

The poison disappears from the plants almost completely within twenty to twenty-five days, and even if the plants were consumed shortly after the application, an impossible quantity would have to be eaten to get a poisonous dose. To illustrate, in the case of the apple, if the entire fruit were eaten, core and all, it would take several barrels at a single sitting to make a poisonous dose (Riley), and with the

cabbage, dusted as recommended above, 28 heads would have to be eaten at one meal to reach this result (Gillette). It is preferable, however, to use other insecticides in the case of vegetables soon to be eaten, and thus avoid all appearance of danger.

INSECTICIDES FOR EXTERNAL SUCKING INSECTS (CONTACT POISONS).

The simple remedies for this class of insects, such as soap, insect powder, sulphur, tobacco decoction, etc., are frequently of value, but need little special explanation. Some brief notes will be given, however, describing the methods of using some of these substances which are easily available and will often be of service, particularly where few plants are to be treated. The standard remedies for this group of insects, viz, crude petroleum, kerosene, and kerosene emulsions, resin washes, lime, sulphur, and salt wash, hydrocyanic-acid gas, and vapor of bisulphide of carbon, will be afterwards treated in the order mentioned.

SOAPS AS INSECTICIDES.

Any good soap is effective in destroying soft-bodied insects, such as plant-lice and young or soft-bodied larvæ. As winter washes in very strong solution, they furnish one of the safest and most effective means against scale insects. The soaps made of fish oil and sold under the name of whale-oil soaps are often especially valuable, but variable in composition and merits. A soap made with caustic potash rather than with caustic soda, as is commonly the case, and not containing more than 30 per cent of water, should be demanded, the potash soap yielding a liquid in dilution more readily sprayed and more effective against insects. The soda soap washes are apt to be gelatinous when cold, and difficult or impossible to spray except when kept at a very high temperature.

For plant-lice and delicate larvæ, such as the pear slug, a strength obtained by dissolving half a pound of soap in a gallon of water is sufficient. Soft soap will answer as well as hard, but at least double quantity should be taken.

As a winter wash for the San Jose and allied scale insects, whale-oil or fish-oil soap is dissolved in water by boiling at the rate of 2 pounds of soap to the gallon of water. If applied hot and on a comparatively warm day in winter, it can be easily put on trees with an ordinary spray pump. On a very cold day, or with a cold solution, the mixture will clog the pump and difficulty will be experienced in getting it on the trees. Trees should be thoroughly coated with this soap wash. Pear and apple trees may be sprayed at any time during the winter. Peach and plum trees are best sprayed in the spring, shortly before the buds swell. If sprayed in midwinter or earlier, the soap solution

seems to prevent the development of the fruit buds, and a loss of fruit for one year is apt to be experienced, the trees leafing out and growing, however, perhaps more vigorously on this account. The soap treatment is perfectly safe for all kinds of trees, and is very effective against the scale. With large trees, or badly infested trees, preliminary to treatment it is desirable with this as well as other applications to prune them back very rigorously. This results in an economy of spray and makes much more thorough and effective work possible. The soap can be secured in large quantities at from $3\frac{1}{2}$ cents to 4 cents a pound, making the mixture cost, as applied to the trees, from 7 cents to 8 cents a gallon.

PYRETHRUM, OR INSECT POWDER.

This insecticide is sold under the names of Buhach and Persian insect powder, or simply insect powder, and is the ground-up flowers of the Pyrethrum plant. It acts on insects externally through their breathing pores, and is fatal to many forms both of biting and sucking insects. It is not poisonous to man or the higher animals, and hence may be used where poisons would be objectionable. Its chief value is against household pests, such as roaches, flies, and ants, and in greenhouses, conservatories, and small gardens, where the use of arsenical poisons would be inadvisable.

It is used as a dry powder, pure or diluted with flour, in which form it may be puffed about rooms or over plants. On the latter it is preferably applied in the evening, so as to be retained by the dew. To keep out mosquitoes, and also to kill them, burning the powder in a tent or room will give satisfactory results.

It may also be used as a spray at the rate of 1 ounce to 2 gallons of water, but in this case should be mixed some twenty-four hours before being applied. For immediate use, a decoction may be prepared by boiling in water from five to ten minutes.

SULPHUR.

Flowers of sulphur is one of the best remedies for plant mites, such as the red spider, the six-spotted orange mite, and the rust mite of citrus fruits. It may be applied in several forms, the simplest of which is its use as a dry powder dusted over the trees with powder bellows or any broad-casting device, preferably in the early morning when the foliage is damp with dew or immediately after a rain. For the rust mite in very moist climates, such as that of Florida, to keep the fruit bright it is sufficient to merely sprinkle the sulphur about under the trees. The flowers of sulphur may be easily applied also with any other insecticide, such as kerosene emulsion, resin wash, or a soap wash, mixing it up first into a paste and then adding it to the spray tank at a rate of from a pound to two pounds to 50 gallons.

Somewhat more uniform results can be obtained perhaps by getting the sulphur into solution, either dissolving it with lye or by boiling it with lime.

In making the lye-sulphur wash, first mix 20 pounds of flowers of sulphur into a paste with cold water, then add 10 pounds of pulverized caustic soda (98 per cent). The dissolving lye will boil and liquefy the sulphur. Water must be added from time to time to prevent burning, until a concentrated solution of 20 gallons is obtained. Two gallons of this is sufficient for 50 gallons of spray, giving a strength of 2 pounds of sulphur and 1 of lye to 50 gallons of water. An even stronger application can be made without danger to the foliage. This mixture can also be used in combination with other insecticides.

The chemical combination of sulphur and lime known as bisulphide of lime is perhaps a better liquid sulphur solution than the last as a remedy for mites. It may be very cheaply prepared by boiling together for an hour or more, in a small quantity of water, equal parts of flowers of sulphur and stone lime. A convenient quantity is prepared by taking 5 pounds of sulphur and 5 of lime and boiling in 3 or 4 gallons of water until the ingredients combine, forming a brownish liquid. This may be diluted to make 100 gallons of spray.

Almost any of the insecticides with which the sulphur application may be made will kill the leaf or rust mites, but the advantage of the sulphur arises from the fact that it forms an adhering coating on the leaves, which kills the young mites coming from the eggs, which are very resistant to the action of insecticides and result in the plants being reinfested unless protected by the sulphur deposit.

A popular fallacy.—A strongly intrenched popular fallacy, often exposed but constantly being revived, is that sulphur is a valuable remedy against insects when put into holes bored into the trunks of trees, the idea being that the sulphur, when plugged in, is carried up by the movement of the sap into the branches and distributed in the foliage, rendering the latter distasteful to insects. In point of fact the sulphur remains exactly where it is placed, and is of no possible advantage from an insecticide standpoint or any other, and furthermore the treatment is mischievous in that it injures to that extent the soundness of the trunk.

PETROLEUM OILS.

The emulsions of kerosene, or coal oil, with soap or milk have long been the standard insecticides for this class of insects, and especially the plant-lice and scale insects, and these emulsions still are the safest and most reliable means of getting these oils upon plants. The use of kerosene in the pure state as an insecticide was early experimented with by Comstock and Hubbard, and the feasibility of such applications was demonstrated, but the greater safety in the use of the emulsions resulted in a discontinuance of the use of the pure oils. Especially

in the last two or three years, however, the use of these oils in the pure state has come into very general vogue, more particularly as winter washes for the San Jose scale and allied scale insects, the value of the crude oil being especially demonstrated by Prof. J. B. Smith. The petroleum oils may also be used mechanically combined with water by means of especially adapted spray pumps.

In addition to its use as a direct application to plants, kerosene is often used as a means of destroying insects by jarring the latter from plants into pans of water on which a little of the oil is floating, or by jarring them upon cloths or screens saturated with kerosene, preferably the crude oil. The same principle is illustrated in some of the hopper-dozers, or machines for collecting locusts and grass-leaf hoppers.

As a remedy for mosquitoes, kerosene has proved very effective. It is employed to destroy the larvæ of the mosquitoes in their favorite breeding places in small pools, still ponds, or stagnant water; and where such bodies of water are not sources of drinking supply or of value for their fish, especially in the case of temporary pools from rains, which frequently breed very disagreeable local swarms, the use of oil is strongly recommended. The kerosene is applied at the rate of 1 ounce to 15 square feet of water surface. It forms a uniform film over the surface and destroys all forms of aquatic insect life, including the larvæ of the mosquito, and also the adult females coming to the water to deposit their eggs. The application retains its efficiency for several weeks, even with the occurrence of heavy rains. A light grade of fuel oil is preferred for this purpose.

The methods of using kerosene in the pure state and as emulsions with soap and milk follow.

Pure kerosene treatment.—This consists in spraying the trees with ordinary illuminating oil (coal oil or kerosene). The application is made at any time during the winter, preferably in the latter part, and by means of a spray pump making a fine mist spray. The application should be attended with the greatest care, merely enough spray being put on the plant to moisten the trunk and branches without causing the oil to flow down the trunk and collect about the base. With the use of this substance it must be constantly borne in mind that careless or excessive application of the oil will be very apt to kill the treated plant. The application should be made on a bright, dry day, so that the oil will evaporate as quickly as possible. On a moist, cloudy day the evaporation is slow, and injury to the plant is more apt to result. If the kerosene treatment be adopted, therefore, it must be with a full appreciation of the fact that the death of the tree may follow. This oil has been used, however, a great many times and very extensively without any consequent injury of any kind. On the other hand, its careless use has frequently killed many valuable trees. Its advantages

are its availability and its cheapness, kerosene spreading very rapidly and much less of it being required to wet the tree than of a soap and water spray. Pure kerosene is more apt to be injurious to peach and plum than to pear and apple trees, and the treatment of the former as with the soap wash should be deferred until spring, just before the buds swell. With young trees especially, it is well to mound up about the trunk a few inches of earth to catch the downflow of oil, removing the oil-soaked earth immediately after treatment.

The crude-petroleum treatment.—Crude petroleum is used in exactly the same way as is the common illuminating oil referred to above. Its advantage over kerosene is that, as it contains a very large percentage of the heavy oils and paraffin, it does not penetrate the bark so readily, and, on the other hand, only the light oils evaporate, leaving a coating of the heavy oils on the bark, which remains in evidence for months and prevents any young scale which may have escaped from the individuals that were not reached by the spray from getting a foothold. Crude petroleum comes in a great many different forms, depending upon the locality, the grade successfully experimented with in the work of this Division showing 43° Baumé. The experience of Prof. J. B. Smith indicates that crude oil showing a lower Baumé than 43° is unsafe and more than 45° is unnecessarily high. The lower specific gravity indicated (43°) is substantially that of the refined product, the removal of the lighter oils in refining practically offsetting the removal of the paraffin. The same cautions and warnings apply to the crude as to the refined oil.

The oil-water treatment.—Various pump manufacturers have now placed on the market spraying machines which mechanically mix kerosene or crude petroleum with water in the act of spraying. The proportion of kerosene can be regulated so that any desirable percentage of oil can be thrown out with the water. A 10-per-cent-strength kerosene can be used for a summer spray on trees where the San Jose scale is multiplying rapidly and it is not desirable to let it go unchecked until the time for the winter treatment. The winter treatment with the water-kerosene sprays may be made at a strength of 20 per cent of the oil. Applications of the oil-water spray should be attended with the same precautions as with the pure oil, and there is even somewhat greater risk, owing to the natural tendency one has to apply the dilute mixture much more freely than the pure oil. The application should be merely enough to wet the bark and should not, to any extent, at least, run down the trunk. The collection of water and oil about the trunk is just as dangerous to the tree as the pure oil.

In the use of the oil sprays noted above, one who has not had experience with them is advised to make some careful preliminary tests to fully master the process. It is well also, with the oil-water mixtures, to test the pump from time to time, spraying into a glass jar or bottle

to determine by actual measurement whether the percentage of oil and water is being properly maintained.

Kerosene emulsion—Soap formula—

Kerosene.....	gallons..	2
Whale-oil soap (or 1 quart soft soap).....	pound..	$\frac{1}{2}$
Water	gallon..	1

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, the emulsion will keep indefinitely, and should be diluted only as wanted for use.

For the treatment of large orchards or in municipal work requiring large quantities of the emulsion, it will be advisable to manufacture it with the aid of a steam or gasoline engine, as has been very successfully and economically done in several instances, all the work of heating, churning, etc., being accomplished by this means.

The use of whale-oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, and does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft soap answers very well, and 1 quart of it may be taken in lieu of the hard soaps.

In limestone regions, or where the water is very hard, some of the soap will combine with the lime or magnesia in the water and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye, or rain water employed; but better than either, follow the milk emulsion formula, with which the character of the water, whether hard or soft, does not affect the result.

The distillate emulsion.—This wash was originated by Mr. F. Kahles, of Santa Barbara, Cal. It has been recommended by the California State Board of Horticulture and has found very general use in the citrus sections of the State. It is substantially an emulsion of crude petroleum made in the same way as the kerosene emulsion described above, except that a greater amount of soap and only half as much oil proportionately is used. The lessened quantity of oil enables it to be made comparatively cheaply, and in spite of this reduction in the oil, the wash is, if anything, stronger than kerosene emulsion, judging from the experience of the writer with both these washes in southern California.

It is termed distillate spray, because the oil used is a crude distillate of the heavy California petroleum. The product used for preparing the emulsion should have a gravity of about 28° Baumé, and is the crude oil minus the lighter oil, or what distills over at a temperature between 250° and 350° C. In general characteristics it is very similar to lubricating oil. The emulsion, or, as it is generically known, "cream," is prepared as follows: Five gallons of 28° gravity distillate; 5 gallons of water, boiling; 1 to 1½ pounds of whale-oil soap. The soap is dissolved in hot water, the distillate added, and the whole thoroughly emulsified by means of a power pump until a rather heavy, yellowish, creamy emulsion is produced. The product is very similar to, but rather darker in color than the ordinary kerosene emulsion. For use on citrus trees it is diluted with from twelve to fifteen parts of water, the stronger wash for the lemon and the weaker for the orange. The "distillate cream" is commonly prepared and sold by oil companies or individuals at from 10 to 12 cents a gallon, making the diluted mixture cost in the neighborhood of a cent a gallon.

In using both of the above emulsions, it is advisable to first break the water by the addition of a little lye, a fourth-pound of lye being ample for 50 gallons of water.

Kerosene emulsion (milk formula)—

Kerosene.....	gallons..	2
Milk (sour)	gallon..	1

Heating is unnecessary in making the milk emulsion, which otherwise is churned as in the former case. The change from a watery liquid to a thick buttery consistency, much thicker than with the soap, takes place very suddenly after three to five minutes' agitation. With sweet milk difficulty will frequently be experienced, and if the emulsion does not result in five minutes, the addition of a little vinegar will induce prompt action. It is better to prepare the milk emulsion from time to time for immediate use, unless it can be stored in quantity in air-tight jars, otherwise it will ferment and spoil after a week or two.

How to use the emulsions.—During the growing period of summer, for most plant-lice and other soft-bodied insects, dilute the emulsion with from 15 to 20 parts of water; for the red spider and other plant mites the same, with the addition of 1 ounce of flowers of sulphur to the gallon; for scale insects, the larger plant-bugs, larvæ, and beetles, dilute with from 7 to 9 parts of water; apply with spray pump.

For winter applications to the trunks and larger limbs of trees in the dormant and leafless condition, to destroy scale insects stronger mixtures may be used, even to the pure emulsion, which latter can not be sprayed successfully, but may be applied with brush or sponge. Diluted with one or more parts of water it may be applied in spray without difficulty. The use of the pure emulsion is heroic treatment and only advisable in cases of excessive infestation, and in general it is much better and safer to defer the treatment until the young scales

hatch in the spring, when the nine-times diluted wash may be used with more certain results and without danger to plants. The winter treatment should be followed by a use of the spring wash to destroy any young which may come from female scales escaping the stronger mixture.

Cautions in use of oil washes.—In the use of kerosene washes, and, in fact, of all oily washes on plants, the application should be just sufficient to wet the plant, without allowing the liquid to run down the trunk and collect about the crown. Usually around the crown, in the case of young trees at least, there is a cavity formed by the swaying of the plants in the wind, and accumulation of the insecticide at this point, unless precautions be taken, may result in the death or injury of the plant. Under these conditions it may be advisable to mound up the trees before spraying and firmly pack the earth about the bases. Care should be taken in refilling the tank that no free oil is allowed to accumulate gradually in the residue left at the bottom, when spraying with emulsions or oil-water mixtures.

THE RESIN WASH.

This wash has proved of greatest value in California, particularly against the red scale (*Aspidiotus aurantii*) and the black scale (*Lecanium olea*) on citrus plants, and the last named and the San Jose scale (*Aspidiotus perniciosus*) on deciduous plants, and will be of use in all similar climates where the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and where, owing to the warmth, the multiplication of the scale insects continues almost without interruption throughout the year. Where rains are liable to occur at short intervals, and in the Northern States, the quicker-acting and stronger kerosene washes and heavy soap applications are preferable. The resin wash acts by contact, having a certain caustic effect, but principally by forming an impervious, smothering coating over the scale insects. The application may be more liberal than with the kerosene washes, the object being to wet the bark thoroughly.

The wash may be made as follows:

Resin	pounds..	20
Crude caustic soda (78 per cent)	do....	5
Fish oil.....	pints..	2½
Water to make	gallons..	100

Ordinary commercial resin is used, and the caustic soda is that put up for soap establishments, in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (98 per cent) used—3½ pounds of the latter being the equivalent of 5 pounds of the former. Place these substances, with the oil, in a kettle with water to cover them to a depth of 3 or 4 inches. Boil about two hours, making occasional additions of water, or until the compound

resembles very strong, black coffee. Dilute to one-third the final bulk with hot water, or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed the mixture should be perfectly fluid, without sediment, and should any appear in the stock mixture reheating should be resorted to, and in fact the wash is preferably applied hot.

As a winter wash for scale insects, and particularly for the more resistant San Jose scale (*Aspidiotus perniciosus*), stronger washes are necessary. In southern California, for this latter insect, the equivalent of a dilution one-third less, or 66 $\frac{2}{3}$ gallons instead of 100, has given very good satisfaction. In Maryland, with this insect, it has proved necessary to use the wash at six times the summer strength to destroy all of the well-protected hibernating scales; and with other scale insects much stronger mixtures than those used in California have proved ineffectual in the East. For regions, therefore, with moderately severe winters the use of the resin wash to destroy hibernating scale insects seems inadvisable.

THE LIME, SULPHUR, AND SALT WASH.

This is the invariable remedy for the San Jose scale in California and much of the Pacific coast, and it is, under the conditions of climate obtaining in that region, undoubtedly very effective. Early experience with this wash in the East threw doubt on its efficiency as an insecticide under the climatic conditions prevailing throughout the eastern half of the United States. Some later experiments, however, have shown that wherever the weather conditions happen to be very favorable, duplicating, in a measure, the conditions on the Pacific coast, this wash is effective in the East also. Unfortunately, the weather conditions can not be relied on, and therefore its use in the East is not recommended. But if a considerable period (ten days or two weeks, at least) of dry weather could be assured after the treatment, it would probably give very satisfactory results when properly made and applied. It is a winter application and is applied in January or February, or at any time prior to spring growth. It may be prepared after the following formula: Unslaked lime, 30 pounds; sulphur, 20 pounds; salt, 15 pounds. Place all together in a barrel with 30 or 40 gallons of water and boil with steam for three or four hours. For use, the mixture should be diluted to make 60 gallons of wash, and may be preferably applied at a high temperature. It may be made in smaller quantities by boiling over a fire, using the same proportion of ingredients. This wash is applied nearly every year, or as often as the San Jose scale develops in any considerable numbers. It has the advantage of leaving a limy coating on the trees, which acts as a deterrent to the young scale lice, and where it is not washed by rains retains its value as an insecticide coating for some time, remaining in evidence on the trees for several months.

This wash is of value also as a fungicide, protecting stone fruits from leaf fungi, and is also a protection against birds, the common California linnet doing great damage to buds in January and February. The wash is almost invariably made and applied by contractors, and costs about 5 cents per gallon applied to the trees.

TIME TO SPRAY FOR SUCKING INSECTS.

For the larger plant-bugs and the aphides, or active plant-lice, and all other sucking insects which are present on the plants injuriously for comparatively brief periods, or at most during summer only, the treatment should be immediate, and if in the form of spray on the plants, at a strength which will not injure growing vegetation.

For scale insects and some others, as the pear *Psylla*, which hibernate on the plants, two or more strengths are advised with most of the liquid insecticides recommended, the weaker for summer applications and the more concentrated as winter washes. The summer washes for scale insects are most effective against the young, and treatment should begin with the first appearance of the larvæ of the spring or any of the later broods, and should be followed at intervals of seven days with two or three additional applications. The first brood, for the majority of species in temperate regions, will appear during the first three weeks in May. Examination from time to time with a hand lens will enable one to determine when the young of any brood appear.

The winter washes may be used whenever summer treatment can not be successfully carried out, and are particularly advantageous in the case of deciduous plants with dense foliage which renders a thorough wetting difficult in summer, or with scale insects which are so irregular in the time of disclosing their young that many summer treatments would be necessary to secure anywhere near complete extermination. In the winter also, with deciduous trees, very much less liquid is required, and the spraying may be much more expeditiously and thoroughly done. In the case of badly infested trees, a vigorous pruning is advisable as a preliminary to treatment.

As winter washes for temperate regions the kerosene washes and whale-oil soap solutions have so far given the best results. In the growing season any of these stronger washes would cause the loss of foliage and fruit, and the more concentrated probably the death of the plant.

THE GAS TREATMENT.

The use of hydrocyanic-acid gas originated in southern California in work against citrus scale insects, and was perfected by a long period of experimentation by an agent of this division, Mr. D. W. Coquillett. It is undoubtedly the most thorough method known of destroying scale insects and especially is it the best treatment for citrus trees, the abundance of foliage and nature of growth of which renders thorough spray-

ing difficult, but, on the other hand, enables the comparatively heavy tents employed in fumigation to be thrown or drawn over the trees rapidly without danger of breaking the limbs. One good gassing is usually the equivalent of two or three sprayings, the gas penetrating to every particle of the surface of the tree and often effecting an almost complete extermination, rendering another treatment unnecessary for two years or more.

The gas treatment is just as effective also against scale insects on deciduous orchard fruit trees, as has been demonstrated by a good deal of work recently done in the East, notably in Maryland by Professor Johnson; but the difficulty and expense of the treatment as measured by the value of the crop protected makes it as a rule prohibitive in the case of deciduous fruits. This does not apply, however, to nursery stock, which may be brought together compactly and treated in mass

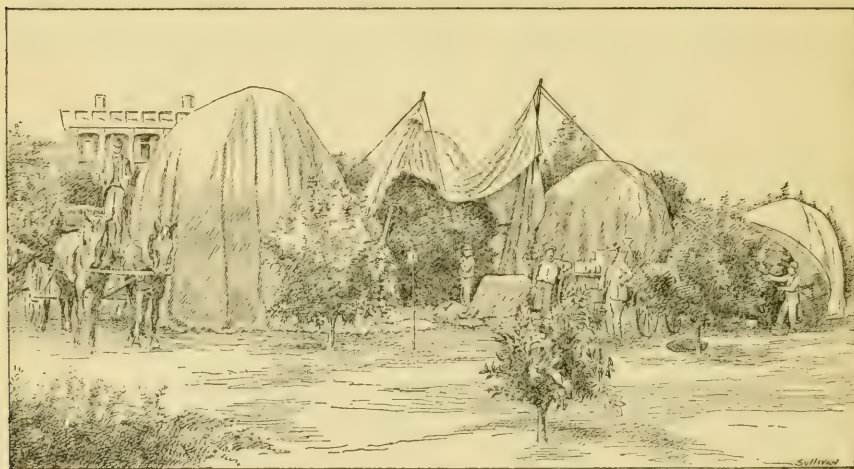


FIG. 3.—Tenting trees for gas treatment, San Diego, Cal. (author's illustration).

in fumigating rooms or houses. The general spread of the San Jose scale in the East has made such fumigation of nursery stock, even when infestation is not shown or suspected, a necessary procedure before shipment or sale, to give the utmost assurance of safety to the purchaser. Similarly this gas is the principal agency employed in disinfecting-plant material coming to California from abroad, and will be the chief agency for such work wherever quarantine regulations prevail. (See fig. 3.)

Another very important use for hydrocyanic-acid gas, recently demonstrated, is as a means of controlling insect pests in greenhouses and cold frames. The process is a special one, however, and entails considerable of variation, owing to the wide range of plants to be considered. The details of the process are given in a special publication of this Division (circular No. 37, second series), which will be supplied to anyone interested.

The employment of this gas for disinfecting houses of insect pests and vermin has also suggested itself and has been a matter of some experimentation, and the feasibility of using the gas for such purposes is not to be questioned. Nevertheless, this gas is so extremely poisonous and deadly that its employment in dwelling-houses can under no circumstances be recommended to anyone who has not had previous experience with it, as the least carelessness would probably mean the loss of human life. For house disinfection the use of the gas is substantially as in fumigation of nursery stock.

In all work with hydrocyanic-acid gas, its extremely poisonous nature must be constantly kept in mind and the greatest precautions taken to avoid inhaling it.

Fumigation of nursery stock.—For the fumigation of nursery stock or imported plant material in a dormant or semi-dormant condition, a building or room should be provided, made so that it can be closed practically air-tight and fitted with means of ventilation above and at the side, operated from without, so that the poisonous gas can be allowed to escape without the necessity of anyone entering the chamber. The gas is generated by combining potassium cyanide, sulphuric acid, and water. The proportions of the chemicals are as follows: Refined potassium cyanide (98 per cent), 1 ounce; commercial sulphuric acid, 1 ounce; water, 3 fluid ounces to every hundred feet of space in the fumigating room. For comparatively green or tender material the same amounts may be used to 150 cubic feet of space.

The generator of the gas may be any glazed earthenware vessel of 1 or 2 gallons capacity and should be placed on the floor of the fumigating room, and the water and acid necessary to generate the gas added to it in the order named. The cyanide should be added last, preferably in lumps the size of a walnut, and the premises promptly vacated and the door made fast. Treatment should continue forty minutes.

Orchard fumigation.—In the fumigation of growing stock, citrus or other, the treatment consists in inclosing the tree with a tent and filling the latter with poisonous fumes generated in the same way as described for nursery stock except that less of the chemicals is used. The treatment is made at night for trees in foliage, which includes all work in citrus orchards, to avoid the much greater likelihood of injury to tender foliage in the sunlight.

The proportions of the chemicals vary with the size of the tree and, as now employed in California, are considerably in excess of the amounts recommended a few years ago, or as recently as 1898. The gas treatment was first chiefly used against the black scale and at a season of the year when these scales were all in a young stage and easily killed. The effort is now made not only to kill the black scale, but also the red scale, and to do more effective work even than formerly with both of these scale insects. The proportion of chemicals ordi-

narily advised and commonly employed in Los Angeles, Orange, and some other counties in southern California are indicated in the subjoined table, published by the horticultural commissioners of Riverside County, Cal.

TABLE 1.—*Proportion of chemicals for ordinary use.*

Height of tree.	Diameter of tree.	Water.	Cyanide, C. P., 98 per cent.	Sulphuric acid, 66 per cent.
<i>Feet.</i>	<i>Feet.</i>	<i>Ounces.</i>	<i>Ounces.</i>	<i>Ounces.</i>
6	4	2	1	1
8	6	3	1½	1½
10	8	5	2½	2½
12	14	11	5	5½
16	16	17	8	9
20	16-20	22	10	12
20-24	18-22	30	14	16
24-30	20-28	34	16	18
30-36	25-30	52	24	28

The amounts here recommended are thoroughly effective for the black scale at the proper season, and generally effective also for the California red scale and other armored scales. Where the treatment is designed to be absolutely one of extermination and the expense is not considered, from one-third to one-half more of cyanide and acid is employed, as indicated by the subjoined table, furnished by Mr. G. Havens, of Riverside. The amounts here recommended may be employed also for compact trees with dense foliage or in moist coast regions where stronger doses are needed.

TABLE 2.—*Excessive amounts employed for absolute extermination.*¹

Height of tree.	Diameter through foliage.	Water.	Sulphuric acid.	Cyanide.	Time to leave tent on tree.
<i>Feet.</i>	<i>Feet.</i>	<i>Fluid ozs.</i>	<i>Fluid ozs.</i>	<i>Ounces.</i>	<i>Minutes.</i>
6	3-4	3	1½	½-1	20
8	5-6	6	2½	2	30
10	7-10	15	5-6	4-5	35-40
12	9-12	20-30	7-9	5½-7½	40
14	12-14	30-35	9-12	8-10	40
16	12-15	35-40	12-14	10-12	40
18	14-16	45-55	15-18	12-15	40-50
20	16-18	60-70	20-22	16-20	45-50
22	16-18	70-75	22-25	20	50
24	18-20	75-80	25-30	22-26	50
27	20-24	85-100	30-36	28-32	60
30	20-28	100-110	36-44	32-38	60

¹A fumigation of the orangery of the Department December 3, 1900, demonstrated that 0.15 of a gram of cyanide to the cubic foot, or a little more than half an ounce to the hundred cubic feet, is completely exterminative of scale insects, effectually killing the eggs, even of the black, purple, and other scales. The strength mentioned is that ordinarily recommended for violet houses, and the results are scarcely comparable to the proportions recommended in Tables 1 and 2, for the reason that in these tables the amount of cyanide is greatly lessened with larger trees, and, furthermore, that the orangery probably retained the gas more effectually than would be the case with cloth tents. Nevertheless, it is interesting to know that a comparatively inconsiderable strength of cyanide, when applied under the best conditions, will prove thoroughly effective against the eggs as well as the insects in all stages.

The duration of the treatment indicated in the second table varies with the size of the tree, but in general at least forty minutes should be allowed.

General directions for orchard fumigation.—The first table indicates for the smaller trees twice as much cyanide and acid as was formerly advised, and for the larger trees three times the former amounts. The second table indicates a considerable increase over the first, and three or four times as much of the chemicals as was generally recommended as late as 1898. The greater expense entailed by this larger quantity of chemicals is offset by the more effective results and the consequently longer intervals between treatments. Mr. Havens suggests that for small trees ordinary earthenware vessels may be used to generate the gas. For large trees requiring heavy doses, tall wooden pails have proven more practicable, using two generators for the very largest trees. It is important that the water be put in the vessel first, and then the acid, and lastly the cyanide. If the water and cyanide are put in the vessel first and the acid poured in afterwards there is danger of an explosion which will scatter the acid and burn the tents and the operator. In the spring, when the trees are tender with new growth, and in early fall when the oranges are nearly grown and the skins are liable to be easily marred, and also with young trees, it is advisable to add one-third more water than ordinarily used, or the cyanide in larger lumps. This causes the gas to generate more slowly and with less heat, and if the tents are left over the trees a third longer the effectiveness of the treatment will not be lessened.

The treatment is made at night, and the person handling the chemicals should always have an attendant with a lantern, to hold up the tent and enable the cyanide to be quickly dropped into the generator, and to facilitate the prompt exit of the operator.

Trees are fumigated for the black scale in southern California in October, or preferably in November. The red and other scales may be treated with gas at any time, but preferably at the season already alluded to. In California most of the work is done by contract, or under the direct supervision of the county horticultural commissioners, in some cases the tents and material being furnished at a mere nominal charge, together with one experienced man to superintend the work, while a crew of four men operate the tents, the wages of the director and men being paid by the owner of the trees.

Construction and handling of tents.—The tents now employed are of two kinds, the "sheet" tent of octagonal shape for large trees, and the "ring" tent for trees under 12 feet in height. The ring tents, or, as they are also called, the bell tents, are bell-shaped and have a hoop of half-inch gas pipe fastened within a foot or so of the opening. Two men can easily throw one of these tents over a small tree. An equipment of 36 or 40 ring tents can be handled by four men. They are rapidly thrown over the trees by the crew, and the director follows

closely and introduces the chemicals. By the time the last tent has been adjusted the first one can be removed and taken across to the adjoining row. An experienced crew, with one director, can treat 350 to 400 five-year-old trees, averaging in height 10 feet, in a single night of eleven or twelve hours. The cost under such conditions averages about 8 cents a tree.

With large trees the large sheet tents are drawn over them by means of uprights and pulley blocks. Two of these sheets are necessary for very large trees, the first being drawn halfway over and the second drawn up and made to overlap the first. In the case of trees from 24 to 30 years old and averaging 30 feet in height, about 50 can be treated in a night of ten or twelve hours with an equipment of 12 or 15 tents, the cost being about 75 cents per tree. It is not practicable to treat trees above 30 feet in height.

The handling of the bell tents is simple and needs no further description, but the large tents are not so easily operated, and the method of adjusting the great flat octagonal sheets over the trees, while simple enough when once understood, warrants a description. The machinery employed consists of two simple uprights, with attached blocks and tackle (fig. 4). The uprights are about 25 feet high, of strong Oregon pine, 2 by 4 inches, and are provided at the bottom with a

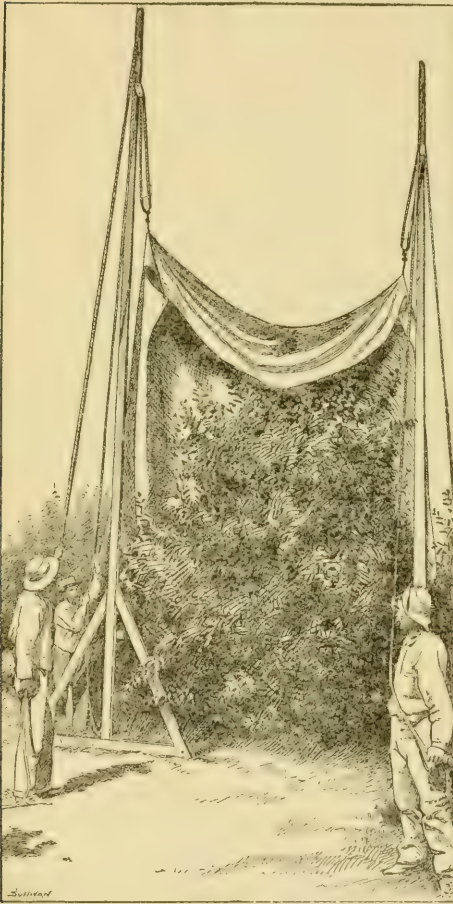


FIG. 4.—Method of hoisting sheet tent (after Craw).

braced crossbar to give them strength and to prevent their falling to either side while the tent is being raised. A guy rope is attached to the top of each pole and held to steady it by two of the crew stationed at the rear of the tree. The tent is hoisted by means of two ropes 70 feet long, which pass through blocks, one fixed at the top of the pole and the other free. The tent is caught near the edge by taking a hitch

around some solid object, such as a green orange, about which the cloth is gathered. By this means the tent may be caught anywhere without the trouble of reversing and turning the heavy canvas to get at rings or other fastenings attached at particular points. The two remaining members of the operating crew draw the tent up against and over one side of the tree by means of the pulley ropes sufficiently to cover the other side of the tree when the tent falls. The poles and tent together are then allowed to fall forward, leaving the tent in position. Sufficient skill is soon acquired to carry out rapidly the details of this operation, so that little time is lost in transferring the tents from tree to tree, even when the trees approximate the limit in height. A single pair of hoisting poles answers for all the tents used.

Some of the tents employed are of great size, one described by Mr. Havens having a diameter of 76 feet. It is constructed of a central piece 50 feet square, of 10-ounce army duck. Four triangular side pieces or flaps of 8-ounce duck, 10 feet wide in the middle, are strongly sewed to each side of the central sheet, forming an octagonal sheet 70 feet in diameter. About the whole sheet is then sewed a strip of 6-ounce duck, 1 yard wide. The tent is handled by means of ropes and pulleys. A 1½-inch manila rope is sewed about the border of the central piece in an octagonal pattern. Rings are attached to this rope at each of the eight corners thus formed, and also on either side of the tent. To these rings the pulley ropes are fastened, and the tent is elevated over the trees and handled very much as indicated in fig. 4.

The canvas for the tents, blue or brown drilling or 8-ounce duck, may be rendered comparatively impervious to the gas by painting lightly with boiled linseed oil. This has the objection, however, of stiffening the fabric and adding considerably to its weight; it also frequently leads to its burning by spontaneous combustion unless carefully watched until the oil is dry. A much better material than oil is found in a product obtained from the leaves of the common prickly pear cactus (*Opuntia engelmanni*), which grows in abundance in the Southwest. The liquor is obtained by soaking chopped-up leaves in water for twenty-four hours. It is given body and color by the addition of glue and yellow ocher or venetian red, and is applied to both sides of the canvas and rubbed well into the fiber of the cloth with a brush.

Some practical experience is necessary to fumigate successfully, and it will therefore rarely be wise for anyone to undertake it on a large scale without having made preliminary experiments.

BISULPHIDE OF CARBON VAPOR.

In line with the use of hydrocyanic-acid gas is the employment of the vapor of bisulphide of carbon to destroy insects on low-growing plants, such as the lice on melon and squash vines. The treatment, as

successfully practiced by Professors Garman and Smith, consists in covering the young vines with small tight boxes 12 to 18 inches in diameter, of either wood or paper, and introducing under each box a saucer containing one or two teaspoonfuls (1 or 2 drams) of the very volatile liquid, bisulphide of carbon. The vines of older plants may be wrapped about the hill and gathered in under larger boxes or tubs, and a greater, but proportional, amount of bisulphide used. The covering should be left over the plants for three-quarters of an hour to an hour, and with 50 to 100 boxes a field may be treated with comparative rapidity.

DUSTING AND SPRAYING APPARATUS.

For the application of powders the dusting bags already described are very satisfactory, or for garden work some of the small powder bellows and blowers are excellent. The best of these cost about \$2 each and are on the market in many styles.



FIG. 5.—Different methods of treating plants for insects (author's illustration).

Better apparatus is required for the wet applications where successful results require the breaking up of the liquid into a fine mist-like spray. The essential features of such an apparatus are a force pump, several yards of one-half-inch cloth-reinforced hose with bamboo hoisting rod, and a spray tip. The size of the apparatus will depend on the amount of vegetation to be treated. For limited garden work and for the treatment of low plants the knapsack pumps or the small bucket force pumps are suitable, the former costing about \$14 and the latter from \$6 to \$9.

Ready-fitted pumps, knapsack, and others, for the application of insecticides, are now made by all the leading pump manufacturers of this country, and also large reservoirs with pump attached for extended orchard operations, the price of the latter ranging from \$25 to \$75.

The cost of a spraying outfit for orchard work may be greatly reduced by combining a suitable pump and fixtures with a home-constructed tank or barrel, to be mounted on a cart or wagon. A spray tank having a capacity of about 150 gallons is a very satisfac-

tory size, and may be conveniently made 4 feet long by $2\frac{1}{2}$ wide by 2 deep, inside measurements. It should be carefully constructed, so as to be water-tight, and should be strengthened by four iron bolts or rods across the ends, one each at the top and bottom. A good double-acting force pump may be obtained from any of the leading pump manufacturers at a cost of from \$10 to \$20, depending upon whether of iron or brass and the nature of its fittings. For use in very large orchards or in city parks it may be advisable to construct the tank of twice the capacity mentioned, to expedite the spraying and to avoid the more frequent refillings necessary with the smaller tank.

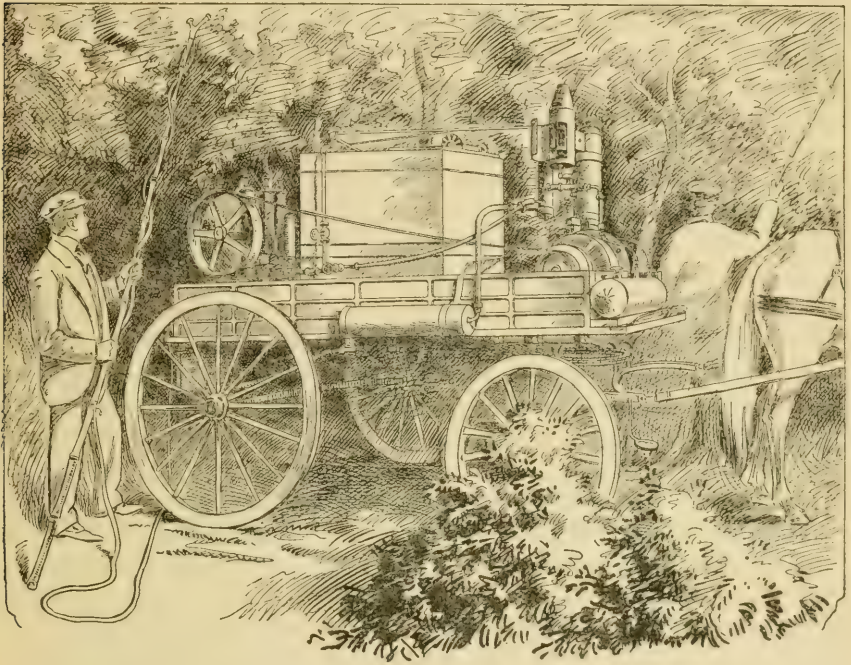


FIG. 6.—Gasoline power spraying outfit of the Division of Entomology, U. S. Department of Agriculture (author's illustration).

For the requirements last mentioned the use of power spraying apparatus of considerable capacity has become somewhat general, particularly in municipal work against shade-tree insects in the East and in spraying the large citrus groves of the Pacific slope. An apparatus of this sort recently built by the Division of Entomology of the Department is illustrated in the accompanying figure (fig. 6). The use of power apparatus for spraying is a special subject, and those interested would do well to consult the article by Dr. L. O. Howard (Yearbook Dept. Agric., 1896, pp. 69–88) giving full descriptive details, with figures, of the important machines now in use.

The more economical spray tips in the amount of liquid required

are the different styles of cyclone nozzles, the best form of which is known to the market generally as the Vermorel nozzle. These are manufactured by the leading spray-pump companies. Other good nozzles are also on the market. The common garden spraying and hose nozzles are much too coarse for satisfactory work, and are wasteful of the liquid.

A prime essential in spraying, especially where the large reservoirs are employed, is to keep the liquid constantly agitated to prevent the settling of the poison to the bottom of the tank. This may be accomplished by constant stirring with a paddle, by shaking, but preferably by throwing a stream of the liquid back into the tank. Many of the larger pumps are now constructed with two discharge orifices with this latter object in view or are provided with special agitators, and the use of such is recommended.

For fruit trees of average size, or, if apple, such as would produce from 10 to 15 bushels of fruit, from 3 to 7 gallons of spray are necessary to wet each tree thoroughly. For smaller trees, such as plum and cherry, 1 gallon to the tree will be sufficient. If an average of 5 gallons to the tree be taken, for an apple orchard of 1,000 trees 5,000 gallons of spray would be required. About 33 pounds of Paris green or London purple would be needed for one spraying if used at the rate of 1 pound to 150 gallons of water, and for the two applications ordinarily recommended 66 pounds. This, for the Paris green, at 20 cents a pound, would amount to \$13.20, and the London purple, at 10 cents a pound, to \$6.60, or a little over 1 cent a tree for the former and one-half a cent for the latter.

In spraying orchard trees it will be found convenient in going between the rows to spray on each side, half of each tree in the row at a time and finish on the return, rather than attempt to spray all sides of one tree before taking up another.

The object in spraying is to coat every leaf and part of the plant as lightly as compatible with thoroughness, and to avoid waste in doing this a mist spray is essential. The application to any part should stop when water begins to drip from the leaves. A light rain will not remove the poison, but a dashing one will probably necessitate a renewal of the application.

REMEDIES FOR SUBTERRANEAN INSECTS.

Almost entire dependence is placed on the caustic washes, or those that act externally, for insects living beneath the soil on the roots of plants, including both sucking and biting insects, prominent among which are the white grubs, maggots in roots of cabbage, radishes, onions, etc., cutworms, wireworms, apple and peach root-lice, the grape phylloxera, and many others.

The insecticide must be one that will go into solution and be carried

down by water. Of this sort are the kerosene emulsions and resin wash—the former preferable—the potash fertilizers, muriate and kainit, and bisulphide of carbon. The simple remedies are in applications of strong soap or tobacco washes to the soil about the crown; or soot, ashes, or tobacco dust buried about the roots; also similarly employed are lime and gas lime. Submersion, wherever the practice of irrigation or the natural conditions make it feasible, has also proved of the greatest service against the phylloxera.

HOT WATER.

As a means of destroying root-lice, and particularly the woolly louse of the apple, the most generally recommended measure hitherto is the use of hot water, and this, while being both simple and inexpensive, is thoroughly effective, as has been demonstrated by practical experience. Water at nearly the boiling point may be applied about the base of young trees without the slightest danger of injury to the trees, and should be used in sufficient quantity to wet the soil thoroughly to a depth of several inches, as the lice may penetrate nearly a foot below the surface. To facilitate the wetting of the roots and the extermination of the lice, as much of the surface soil as possible should be first removed.

By a hot-water bath slightly infested stock can easily be freed of the aphides at the time of its removal from the nursery rows. The soil should be dislodged and the roots pruned, and in batches of a dozen or so the roots and lower portion of the trunk should be immersed for a few seconds in water kept at a temperature of 130° to 150° F. A strong soap solution similarly heated or a fifteen times diluted kerosene emulsion will give somewhat greater penetration and be more effective, although the water alone at the temperature named should destroy the lice.

Badly infested nursery stock should be destroyed, since it would be worth little even with the aphides removed.

TOBACCO DUST.

Some very successful experiments conducted by Prof. J. M. Stedman demonstrated the very satisfactory protective, as well as remedial, value of finely ground tobacco dust against the woolly aphid. The desirability of excluding the aphid altogether from nursery stock is at once apparent, and this Prof. Stedman shows to be possible by placing tobacco dust freely in the trenches in which the seedlings or grafts are planted and in the orchard excavations for young trees. Nursery stock may be continuously protected by laying each spring a line of the dust in a small furrow on either side of the row and as close as possible to the tree, covering loosely with earth. For large trees, both for protection and the destruction of existing aphides, from 2 to 5

pounds of the dust should be distributed from the crown outward to a distance of 2 feet, first removing the surface soil to a depth of from $\frac{1}{2}$ to 6 inches. The tobacco kills the aphides by leaching through the soil, and acts as a bar for a year or so to reinfestation. The dust is a waste product of tobacco factories, costs about 1 cent per pound, and possesses the additional value of being worth fully its cost as a fertilizer.

KEROSENE EMULSION AND RESIN WASH.

Either the kerosene and soap emulsion or the resin wash, the former diluted 15 times and the latter at the strength of the winter mixture, are used to saturate the soil about the affected plants and either left to be carried down by the action of rains or washed down to greater depths by subsequent waterings.

For the grape phylloxera or the root-louse of the peach or apple, make excavations 2 or 3 feet in diameter and 6 inches deep about the base of the plant and pour in 5 gallons of the wash. If not a rainy season, a few hours later wash down with 5 gallons of water and repeat with a like amount the day following. It is better, however, to make this treatment in the spring, when the more frequent rains will take the place of the waterings.

For root-maggots enough of the wash is put along at the base of the plant to wet the soil to a depth of 1 to 2 inches, preferably followed after an hour with a like amount of water.

For white grubs in strawberry beds or in lawns the surface should be wetted with kerosene emulsion to a depth of 2 or 3 inches, following with copious waterings to be repeated for two or three days. The larvæ go to deeper and deeper levels and eventually die.

POTASH FERTILIZERS.

For white grubs, wireworms, cutworms, corn root-worms, and like insects, on the authority of Prof. J. B. Smith, either kainit or the muriate of potash, the former better, are broadcasted in fertilizing quantities, preferably before or during a rain, so that the material is dissolved and carried into the soil at once. These not only act to destroy the larvæ in the soil, but are deterrents, and truck lands constantly fertilized by these substances are noticeably free from attacks of insects. This, in a measure, results from the increased vigor and greater resistant power of the plant, which of itself more than compensates for the cost of the treatment. The value of these fertilizers against the wireworms is, however, questioned by Prof. J. H. Comstock.

For the root-louse of peach and apple, work the fertilizer into the general surface of the soil about the trees, or put it in a trench about the tree 2 feet distant from the trunk.

For cabbage and onion maggots apply in little trenches along the roots at the rate of 300 to 500 pounds to the acre, and cover with soil.

These fertilizers (and the nitrate of soda is nearly as good) are also destructive to the various insects which enter the soil for hibernation or to undergo transformation.

BISULPHIDE OF CARBON.

This is the great French remedy for the phylloxera, 150,000 acres being now subjected to treatment with it, and applies equally well to all other root-inhabiting lice. The treatment is made at any season except the period of ripening of the fruit and consists in making holes about the vines 1 foot to 16 inches deep and pouring into each about one-half ounce of bisulphide, and closing the hole with the foot. These injections are made about $1\frac{1}{2}$ feet apart, and not closer to the vines than 1 foot. It is better to make a large number of small doses than a few large ones. Hand injectors and injecting plows are employed in France to put the bisulphide into the soil about the vines, but a short stick or iron bar may be made to take the place of these injectors for limited tracts.

The use of bisulphide of carbon for the woolly aphis is the same as for the grape root-louse. It should be applied in two or three holes about the tree to a depth of 6 to 12 inches and not closer than $1\frac{1}{2}$ feet to the crown. An ounce of the chemical should be introduced into each hole, which should be immediately closed.

For root-maggots a teaspoonful is poured into a hole near the base of the plant, covering as above.

For ant nests an ounce of the substance is poured into each of several holes made in the space occupied by the ants, the openings being then closed; or the action is made more rapid by covering with a wet blanket for ten minutes and then exploding the vapor at the mouth of the holes with a torch, the explosion driving the fumes more thoroughly through the soil.

SUBMERSION.

This very successful means against the phylloxera is now practiced oversome 75,000 acres of vineyards in France which were once destroyed by the grape root-louse, and the production and quality of fruit has been fully restored. In this country it will be particularly available in California and in all arid districts where irrigation is practiced: otherwise it will be too expensive to be profitable. The best results are secured in soils in which the water will penetrate rather slowly, or from 6 to 18 inches in twenty-four hours: in loose, sandy soils it is impracticable on account of the great amount of water required. Submersion consists in keeping the soil of the vineyard flooded for from eight to twenty days after the fruit has been gathered and active growth of the vine ceased, or during September or October, but while

the phylloxera is still in active development. Early in September eight to ten days will suffice; in October fifteen to twenty days, and during the winter, as was formerly practiced, forty to sixty days. Supplementing the short fall submergence a liberal July irrigation, amounting to a forty-eight hour flooding, is customary to reach any individuals surviving the fall treatment, and which in midsummer are very susceptible to the action of water.

To facilitate the operation, vineyards are commonly divided by embankments of earth into square or rectangular plots, the former for level and the latter for sloping ground, the retaining walls being protected by coverings of reed grass, etc., during the first year, or until they may be seeded to some forage plant.

This treatment will destroy many other root-attacking insects and those hibernating beneath the soil, and, in fact, is a very ancient practice in certain oriental countries bordering the Black Sea and the Grecian Archipelago.

REMEDIES FOR INSECTS AFFECTING GRAIN AND OTHER STORED PRODUCTS.

GENERAL METHODS OF TREATMENT.

The chief loss in this direction from insects is to grains in farmers' bins, or grain or grain products in stores, mills, and elevators, although in the warmer latitudes much of the injury results from infestation in the field between the ripening of the grain and its storage in bins or granaries. Fortunately, the several important grain insects are amenable to like treatment. Aside from various important preventive considerations, such as, in the South, prompt thrashing of grain after harvesting, the thorough cleansing of bins before refilling, constant sweeping, removal of waste harboring insects from all parts of granaries and mills, and care to prevent the introduction of "weeviled" grain, there are three valuable remedial measures, viz. agitation of the grain, heating, and dosing with bisulphide of carbon.

The value of agitating or handling grain is well known, and whenever, as in elevators, grain can be transferred or poured from one bin into another grain pests are not likely to trouble. The benefit will depend upon the frequency and thoroughness of the agitation, and in France machines for shaking the grain violently have been used with success. Winnowing weeviled grain is also an excellent preliminary treatment.

Raising the temperature of the grain in closed retorts or revolving cylinders to 130° to 150° F. will kill the inclosed insects if continued for from three to five hours, but is apt to injure the germ, and is not advised in case of seed stock. The simplest, cheapest, and most effectual remedy is the use of bisulphide of carbon.

BISULPHIDE OF CARBON.

This is a colorless liquid with very offensive odor, which, however, passes off completely in a short time. It readily volatilizes and the vapor, which is very deadly to insect life, is heavier than air and settles and fills any compartment or bin in the top of which the liquid is placed. It may be distributed in shallow dishes or tins or in saturated waste on the top of grain in bins, and the gas will settle and permeate throughout the mass of the grain. In large bins, to hasten and equalize the operation, it is well to put a quantity of the bisulphide in the center of the grain by thrusting in balls of cotton or waste tied to a stick and saturated with the liquid, or by means of a gas pipe loosely plugged at one end, down which the liquid may be poured and the plug then loosened with a rod. Prof. H. E. Weed reports that in Mississippi the chemical is commonly poured directly onto the grain. In moderately tight bins no further precaution than to close them well need be taken, but in open bins it will be necessary to cover them over with a blanket to prevent the too rapid dissipation of the vapor. The bins or buildings should be kept closed from twenty-four to thirty-six hours, after which a thorough airing should be given them.

Limited quantities at a time may often be advantageously subjected to treatment in small bins before being placed for long storage in large masses, and especially whenever there is danger of introducing infested grain.

The bisulphide is applied at the rate of 1 pound to the ton of grain, or a pound to a cubic space 10 feet on a side.

In the case of mills, elevators, or larger granaries the application may be best made on Saturday night, leaving the building closed over Sunday, with a watchman without to see that no one enters, and to guard against fire. The bisulphide should be first distributed in the lower story, working upward to avoid the settling vapor, using the substance very freely, in waste or dishes, at all points of infestation and over bins throughout the building.

This insecticide may also be used in other stored products, as peas, beans, etc., and very satisfactorily where the infested material can be inclosed in a tight can, chest, or closet for treatment. It may also be employed to renovate and protect wool or similar material stored in bulk.

The bisulphide costs, in 50-pound cans, 10 cents per pound, and in small quantities, of druggists, 25 to 35 cents per pound.

Caution.—The bisulphide may be more freely employed with milling grain than that intended for seeding, since when used excessively it may injure the germ. It must always be remembered that the vapor is highly inflammable and explosive, and that no fire or lighted cigars, etc., should be in the building during its use. If obtained in large quantities it should be kept in tightly closed vessels and away from fire, preferably in a small out-building.

GENERAL CONSIDERATIONS ON THE CONTROL OF INSECTS.

ADVANTAGE OF PROMPT TREATMENT.

The importance of promptness in the treatment of plants attacked by insects can not be too strongly insisted upon. The remedy often becomes useless if long deferred, the injury having already been accomplished or gone beyond repair. If, by careful inspection of plants from time to time, the injury can be detected at the very outset, treatment is comparatively easy and the result much more satisfactory. Preventive work, therefore, should be done as much as possible, rather than waiting for the remedial treatment later; the effort being to forestall any serious injury rather than to patch up damage which neglect has allowed to become considerable.

KILLING INSECTS AS A PROFESSION.

It may often happen that the amount of work in a community is sufficient to induce one or more persons to undertake the treatment of plants at a given charge per tree or per gallon of the insecticide employed. Where this is the case, and the contracting parties are evidently experienced and capable, it is frequently more economical in the end to employ such experienced persons, especially when a guarantee is given, rather than attempt to do the work one's self with the attending difficulty of preparing insecticides and securing apparatus for work on a comparatively small scale. In California this is a common practice, and also in some of our Eastern cities, and has worked excellently.

THE DETERMINATION OF THE RESULT OF TREATMENT.

It is often of importance to know when and how to determine the effect of any treatment applied directly to insects exposed on the surface of plants. In the case of scale insects, especially during the dormant condition in winter, the response to insecticides is very slow and gradual. The scale larvæ, or any young scales during the growing season, are killed in a few minutes, or a few hours at the furthest, just as any other soft-bodied insect, but the mature scale does not usually exhibit the effects of the wash or gas for some time. Little can be judged, ordinarily, of the ultimate results before two weeks, and it is often necessary to wait one or even two months to get final conclusions. In the case of liquid washes the slow progressive death of the scales is apparently due to the gradual penetration of the insecticide, and also to the softening and loosening of the scale itself, enabling subsequent weather conditions of moisture and cold to be more fatal.

With such biting insects as caterpillars and slug worms after treatment with arsenicals or other poisons death rapidly follows, the time being somewhat in proportion to the size of the larvæ and their natural vigor. Soft-bodied larvæ, such as the slug worms and very young

larvæ of moths and beetles or other insects, are killed in a day or two. Large and strong larvæ sometimes survive the effect of poison for eight or ten days, and leaf-feeding beetles will often fly away and perish from the poison in their places of concealment.

Many larvæ or other forms of leaf-feeding insects, after taking one or two meals of poisoned foliage, will remain in a semitorpid and diseased condition on the plants for several days before they finally succumb. The protection to the plant, however, is just as great as though they had died immediately, but misapprehension may often arise and the poison may be deemed to have been of no service.

The complete extermination of insects on plants is often a very difficult, if not an impossible, undertaking. This is especially true of scale insects. In California even, where the work against these enemies of fruits has been most thorough and successful, experience has shown that the best that can be done is a practical elimination of the scale for the time being, and it is often necessary to repeat the treatment every year or two. In exceptional cases once in three years suffices. With leaf-feeding insects it is often possible to effect complete extermination with the use of arsenical poisons. Such sucking insects as plant-lice may also be completely exterminated. But in general all applications or methods of treatment must be recognized, more or less, as a continuous charge on the crop, as much so as are the ordinary cultural operations.

CONTROL OF INSECTS BY CULTURAL METHODS.

It is much easier to ward off an attack of insects or to make conditions unfavorable for their multiplication than to destroy them after they are once in possession; and in controlling them, methods and systems of farm and orchard culture have long been recognized as of the greatest value, more so even than the employment of insecticides, which, in most cases, can only stop an injury already begun. Insects thrive on neglect, multiply best in land seldom or never cultivated, and winter over in rubbish, prunings, or the undisturbed soil about their food plants, and become, under these conditions, more numerous every year. It is a fact of common observation that it is the neglected farm, vineyard, or orchard filled with weeds or wild growth which is certain to be stocked with all the principal insect enemies; and, on the other hand, thorough and constant culture, with the removal and burning of prunings, stubble, and other waste, the collection and destruction of fallen and diseased fruit, and the practice, where possible, of fall plowing to disturb the hibernating quarters of field insects, will almost certainly be accompanied by comparative immunity from insect pests.

The vigor and healthfulness of plant growth has also much to do with freedom from insect injury, such plants seeming to have a native power of resistance which renders them, in a measure, distasteful to

most insects, or at least able to throw off or withstand their attacks. A plant already weakened, however, or of lessened vitality from any cause, seems to be especially sought after, is almost sure to be the first affected, and furnishes a starting point for general infestation. Anything, therefore, which aids good culture in keeping plants strong and vigorous, such as the judicious use of fertilizers, will materially assist in preventing injury.

To the constant cropping of large areas of land year after year to the same staple is largely due the excessive loss from insects in this country as compared with European countries, because this practice furnishes the best possible conditions for the multiplication of the enemies of such crops. A most valuable cultural means, therefore, is a system of rotation of crops which will prevent the gradual yearly increase of the enemies of any particular staple by the substitution every year or two of other cultures not subject to the attacks of the insect enemies of the first.

With such insects as the Hessian fly, the squash borers, and many others which have regular times of appearance, much can be done, also, by the planting of early or late varieties, or by deferring seeding so as to avoid the periods of excessive danger. Wherever possible, varieties should be selected which experience has shown to be resistant to insect attack. Familiar illustrations of such resistant varieties in all classes of cultivated plants will occur to every practical man, and a better instance of the benefit to be derived from taking advantage of this knowledge can not be given than the almost universal adoption of resistant American vines as stocks for the regeneration of the vineyards of France destroyed by the phylloxera and for the similarly affected vineyards of European grapes in California.

In the case of stored grain pests, particularly the Angoumois moth, or so-called fly weevil, the chief danger in the South is while the grain is standing in shock or stack, after harvesting, during which period the insects have easy access to it. This source of infestation may be avoided by promptly thrashing grain after harvesting and storing it in bulk. This will prevent the injury of more than the surface layer, as the insects are not likely to penetrate deeply into the mass of the grain.

These general notes are by no means new, but their importance justifies their repetition, as indicating the best preventive measures in connection with the remedial ones already given.

THE PROFIT IN REMEDIAL MEASURES.

The overwhelming experience of the past dozen years makes it almost unnecessary to urge, on the ground of pecuniary returns, the adoption of the measures recommended in the foregoing pages against insects. To emphasize the value of such practice it is only necessary

to call attention to the fact that the loss to orchard, garden, and farm crops frequently amounts to from 15 to 75 per cent of the entire product, and innumerable instances could be pointed out where such loss has been sustained year after year, while now, by the adoption of remedial measures, large yields are regularly secured with an insignificant expenditure for treatment. It has been established that in the case of the apple crop spraying will protect from 50 to 75 per cent of the fruit which would otherwise be wormy, and that in actual marketing experience the price has been enhanced from \$1 to \$2.50 per barrel, and this at a cost of only about 10 cents per tree for labor and material. This is especially true of regions where the codling moth has but one fall brood annually.

In the case of one orchard in Virginia, only one-third of which was sprayed, the result was an increase in the yield of sound fruit in the portion treated of nearly 50 per cent, and an increase of the value of this fruit over the rest of 100 per cent. The loss from not having treated the other two-thirds was estimated at \$2,500. The saving to the plum crop and other small fruits frequently amounts to the securing of a perfect crop where otherwise no yield whatever of sound fruit could be secured.

An illustration in the case of field insects may also be given where, by the adoption of a system of rotation, in which oats were made to alternate with corn, the owner of a large farm in Indiana made a saving of \$10,000 per year, this amount representing the loss previously sustained annually from the corn root-worm. The cotton crop, which formerly in years of bad infestation by the leaf-worm was estimated to be injured to the extent of \$30,000,000, is now comparatively free from such injury owing to the general use of arsenicals.

Facts of like import could be adduced in regard to many other leading staples, but the foregoing are sufficient to emphasize the money value of intelligent action against insect enemies, which, with the present competition and diminishing prices, may represent the difference between a profit and a loss in agricultural operations.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

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FARMERS' BULLETIN No. 127.

IMPORTANT INSECTICIDES.

DIRECTIONS FOR THEIR PREPARATION AND USE.

[SECOND REVISION.]

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., March 2, 1908.

SIR: I have the honor to transmit herewith a second revision of Farmers' Bulletin No. 127, on insecticides. The five years that have elapsed since the last revision of this publication have brought some important additions to our knowledge of insecticides and have necessitated some changes of old formulas. These additions and corrections have been incorporated in this revision. As stated in the letter of transmittal to the first edition, this bulletin supplants Farmers' Bulletin No. 19, prepared in 1894 by Mr. C. L. Marlatt, then First Assistant Entomologist. The latter publication, having gone through four slightly revised editions, was in large part rewritten by Mr. Marlatt early in 1901 and issued under the new number to take the place of the older publication.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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IMPORTANT INSECTICIDES: DIRECTIONS FOR THEIR PREPARATION AND USE.

INTRODUCTORY.

Without going minutely into the field of remedies and preventives for insect depredations it is proposed to give in this bulletin brief directions concerning a few of the insecticide agents having the widest range and attended with the greatest usefulness, economy, and ease of application. These are not covered by patents, and in general it is true that the patented articles are inferior, many of the better of them being in fact merely more or less close imitations of the standard substances and compounds hereinafter described. Only such brief references to food and other habits of insects will be included as are necessary to illustrate the principles underlying the use of the several insecticide agents.

RELATION OF FOOD HABITS TO REMEDIES.

For the intelligent and practical employment of insecticides it is necessary to comprehend the nature and method of injury commonly due to insects. Omitting for the present purpose the exceptional forms of injury which necessitate peculiar methods of treatment, the great mass of the harm to growing plants from the attacks of insects falls under two principal heads based on distinct principles of food economy, viz, whether the insect is a biting (mandibulate) or a sucking (haustellate) species. Each group involves a special system of treatment.

INJURY FROM BITING INSECTS.

The biting or gnawing insects are those which actually masticate and swallow some portion of the solid substance of the plant, as the wood, bark, leaves, flowers, or fruit. They include the majority of the injurious larvæ, many beetles, and the grasshoppers. (See fig. 1.)

For these insects direct poisons, such as the arsenicals, which may be safely applied to the leaves or other parts of the plant attacked,

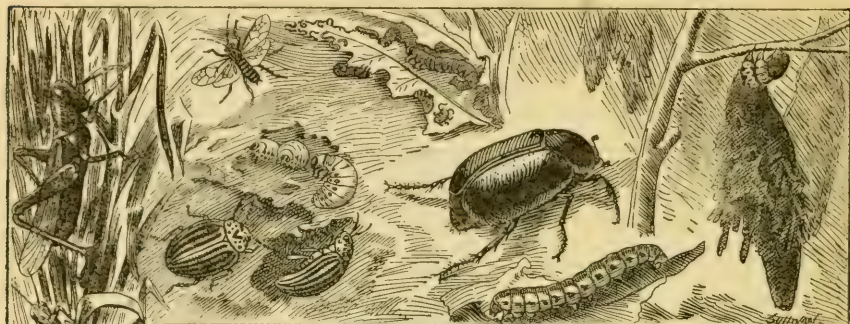


FIG. 1.—Illustrating the different classes of biting insects. All natural size. (Author's illustration.)

and which will be swallowed by the insect with its food, furnish the surest and simplest remedy, and should always be employed, except where the parts treated are themselves to be shortly used for the food of animals or of man.

INJURY FROM SUCKING INSECTS.

The sucking insects are those which injure plants by the gradual extraction of the juices from the bark, leaves, or fruit, and include the plant-bugs, aphides, scale insects, thrips, and plant-feeding mites. These insects possess, instead of biting jaws, sucking beaks or bristles, which are thrust down through the outer layers of the bark or leaves

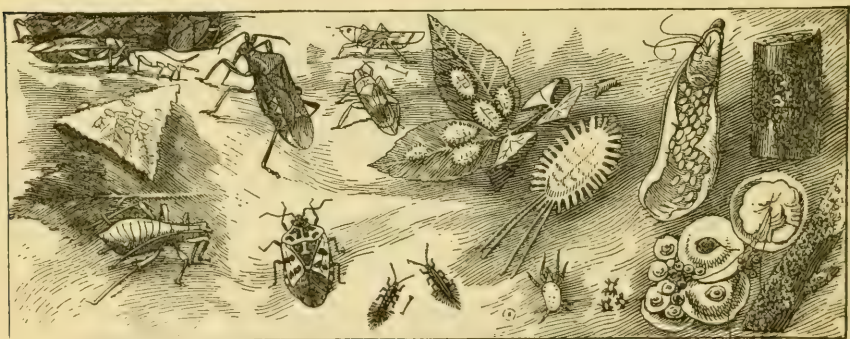


FIG. 2.—Illustrating the different classes of sucking insects. Natural size and enlarged. (Author's illustration.)

into the soft, succulent tissues beneath and used to extract the plant juices, with a resulting injury not so noticeable as in the first group, but not less serious. (See fig. 2.)

For this class of insects the application of poisons, which penetrate little, if at all, into the plant cells, is of trifling value, and it is necessary to use substances which will act externally on the bodies of these insects as a caustic, or will smother or stifle them by closing their breathing pores, or will fill the air about them with poisonous fumes. Of value also as repellents are various deterrent or obnoxious substances.

Where it is not desirable to use poisons for biting insects some of the means just enumerated may often be employed.

GROUPS SUBJECT TO SPECIAL TREATMENT.

The two general groups outlined above comprise the species which live and feed upon the exterior of plants for some portion or all of their lives, and include the great majority of the injurious species. Certain insects, however, owing to peculiarities of habit, inaccessibility, or other causes, require special methods of treatment. Of these, two groups properly come within the scope of this bulletin: (1) Those working beneath the soil, or subterranean insects, such as the white grubs, root maggots, root aphides, etc.; and (2) insects affecting stored products, as various grain and flour pests.

Three other groups, which include species requiring very diverse methods of treatment, and which are not considered in this bulletin, are (1) such internal feeders as wood, bark, and stem borers, leaf miners, and gall insects, and species living within fruits; (2) household pests; and (3) animal parasites.

The classification of insects outlined above, based on mode of nourishment, and indicating groups amenable to similar remedial treatment, simply stated, is as follows:

I. External feeders:

(a) Biting insects.

(b) Sucking insects.

II. Internal feeders.

III. Subterranean insects.

IV. Insects affecting stored products.

V. Household pests.

VI. Animal parasites.

INSECTICIDES FOR EXTERNAL BITING INSECTS (FOOD POISONS).

THE ARSENICALS.

The arsenical compounds have supplanted practically all other substances for insects falling under this heading. Of these, Paris green is the best known and most generally employed, and probably from 2,000 to 3,000 tons of it are used for horticultural purposes every year. Arsenate of lead is a new arsenical coming into very general use, and arsenite of copper, a near ally of Paris green, is also increasingly employed. Arsenite of lime is usually a home preparation, and London purple, the least uniform in composition of all the mixtures, is rather going out of use. The powdered white arsenic or

arsenious oxide can not be employed on account of its scalding action on the foliage, and in the case of any of the arsenicals the percentage of soluble arsenic (arsenious oxide) should be at the very minimum, certainly not in excess of 3 or 4 per cent. With more than 4 per cent soluble arsenic there is great danger of scalding the foliage, the danger increasing with the percentage of soluble arsenic.^a

Paris green.—Paris green is a definite chemical compound of white arsenic, copper oxide, and acetic acid, and is known as the aceto-arsenite of copper. Properly compounded and washed, it should be substantially uniform in composition and nearly free from uncombined soluble white arsenic. It is a rather coarse powder, or, more properly speaking, crystal, and settles rapidly in water, which is its greatest fault. To give better suspension in water, it should be reduced to such fineness by grinding that it will pass through a 100-mesh sieve. Its high cost (varying from 20 to 40 cents a pound, following the market price of copper and arsenic) is further increased by its being crystallized with acetic acid, making it a more brilliant pigment, but giving it a coarse grain and rendering it a poorer insecticide. The standards of purity demanded by various States have led most manufacturers to produce a very fair article, but if there is any doubt of purity a sample should be submitted to the State Experiment Station or to the United States Department of Agriculture for analysis.

Copper arsenite.—Copper arsenite, often called Scheele's green, is the simple arsenite of copper, differing from Paris green in lacking acetic acid. It is a much finer powder than Paris green and therefore is more easily kept in suspension, and it costs considerably less per pound. It is dull in color, lacking the brilliancy of Paris green. When properly prepared and washed by the manufacturers, it is no more harmful to the foliage than Paris green when the latter is brought to an equal fineness, and should supplant the latter as an insecticide. It is used in the same way and at about the same strength as Paris green.

^a *Hellebore.*—The powdered roots of the white hellebore (*Veratrum viride*) are often recommended and used as an insecticide, particularly as a substitute for the arsenites. This substance is useful when a few plants only are to be sprayed, as in yards and small gardens, but is too expensive for large operations. It kills insects in the same way as the arsenicals, as an internal poison, and is less dangerous to man and the higher animals; but if a sufficient amount be taken it will cause death. It is particularly effective against the larvæ of sawflies, such as the cherry slug, rose slug, currant worms, and strawberry worms.

It may be applied as a dry powder, preferably diluted with from 5 to 10 parts of flour, and dusted on the plants through a muslin bag or with powder bellows. The application should be made in the morning, when the plants are moist with dew. Used as a wet application, it should be mixed with water in the proportion of 1 ounce to the gallon of water and applied as a spray.

Arsenite of lime.—This is normally a home-made preparation, and there is no reason for its not being employed wherever one is willing to take the trouble to compound it carefully. Its preparation, described below, following substantially the Kedzie formula, is simple enough:

White arsenic.....	pounds..	1
Crystal sal soda ^a	do.....	4
Water	gallons..	1

Place the above ingredients in an iron vessel, which is to be kept exclusively for this purpose, and boil for twenty minutes or until dissolved. To 40 or 50 gallons of water a pint of this stock solution and 3 to 4 pounds of freshly slaked lime are added. This excess of lime not only takes up any free arsenic, but by its distribution on the foliage enables one to determine how well the spraying has been done. This formula has been thoroughly tested and used now for many years, and is fully as efficient as any other arsenical and far cheaper. Chemically it is arsenite of lime. The soda is used to hasten the process and to insure the combination of all the arsenic with the lime. The greatest care should be exercised in preparing the stock mixture, and afterwards it should be plainly labeled to prevent its being mistaken for some other substance. The only objection to its use is the necessity of handling the poisons in its home preparation.

London purple.—London purple is a waste product in the manufacture of aniline dyes and contains a number of substances, the chief of which are white arsenic and lime. It is not so effective as the copper arsenites, and contains a much larger percentage of soluble arsenic, and is very apt to scald foliage unless very carefully mixed with fresh stone lime. It comes as a very fine powder, and is easily kept in suspension. It costs about 10 cents a pound. If employed, the lime should always be added.

Arsenate of lead.—Arsenate of lead may be prepared at home by combining approximately 3 parts of the crystallized arsenate of soda with 7 parts of crystallized acetate of lead (sugar of lead) in water. This gives a slight excess of acetate of lead. Each of the ingredients should be dissolved separately in water in wooden vessels, and the two solutions poured together into the spray tank filled with water. The white, flocculent precipitate of arsenate of lead which immediately results is extremely fine and remains in suspension much longer than any other arsenical. Furthermore, prepared in this way and diluted at once, there is secured a mixture that is chemically superior to the combined product sold in paste form and that remains in

^a Two pounds only of the *anhydrous* sal soda are necessary.

suspension better. Arsenate of soda costs wholesale about 10 cents a pound, and first-class acetate of lead about 10 cents a pound.

Arsenate of lead may be used at any strength from 3 to 15 pounds to 100 gallons of water without injury to the foliage, for the reason that it contains little, if any, soluble arsenic. It is ordinarily used at the rate of 4 to 6 pounds to the 100 gallons of water or Bordeaux mixture. In later years it has come into general use, especially for spraying plants sensitive to arsenical poisoning, such as peach, and also in cases where it is necessary to make heavy applications. Its safety as regards the burning of foliage and its adhesive quality offset its greater cost, and it is now much used in the codling moth work and general arsenical spraying.

In the home preparation of this arsenical, the number of pounds of the poison per 100 gallons of water as given in directions for use should be understood to mean the combined weights of the two ingredients. In point of fact, the resulting lead arsenate is only about half the actual weight of the two ingredients, which explains in part the apparently excessive amounts used as compared with other arsenicals.

A good many brands of arsenate of lead can be purchased on the market, usually in the form of heavy pastes. As already indicated, they have not the same power of remaining in suspension as the freshly made product, but are otherwise, if properly made, quite satisfactory. The water content, which is variable, should be specifically indicated and guaranteed, to make it possible to use the poison at the strength desired.

Arsenite of lead is a compound very similar to the arsenate of lead, but it contains a less percentage of arsenic. It is prepared from sodium arsenite.

General considerations.—In point of solubility and corresponding danger of scalding the foliage, these arsenicals fall in the following order, the least soluble first: Arsenate of lead, arsenite of lime, Paris green, copper arsenite, and London purple. In point of cost the arsenite of lime is much cheaper than the other arsenicals, and the arsenate of lead, at the rate at which it is necessary to use it, much the most expensive. But after all the main cost is in the application, and it is therefore well worth while to secure a good arsenical and get the best results.

HOW TO APPLY ARSENICALS.

There are three principal methods of applying arsenicals. The wet method, which consists in using these poisons in water in the form of spray, is the standard means, secures uniform results at least expense, and is the only practical method of protecting fruit and shade trees.

The dry application of these poisons in the form of a powder, which is dusted over plants, is more popular as a means against the cotton worm in the South, where the rapidity of treatment possible by this method, and its cheapness, give it a value against this insect, in the practical treatment of which prompt and economical action are the essentials. This method is also feasible for any low-growing crop, such as potatoes, young cabbages, or other plants not to be immediately employed as food. The third method consists in the use of the arsenicals in the form of poisoned baits, and is particularly available for such insects as cutworms, wireworms, and grasshoppers in local invasions.

The wet method.—Either Paris green, arsenite of copper, arsenite of lime, or London purple may be used at the rate of 1 pound of the poison to 100 to 250 gallons of water, or 1 ounce to 6 to 15 gallons. The stronger mixtures are for such vigorous foliage as that of the potato, and the greater dilutions for the more tender foliage of the peach or plum. An average of 1 pound to 150 gallons of water is a good strength for general purposes. The poison should first be made into a thin paste in a small quantity of water and quicklime added in amount equal to the poison used, to take up the free arsenic and remove or lessen the danger of scalding. An excess of lime will do no injury. The poisons thus mixed should be strained into the spray tank or reservoir, care being taken that all the poison is pulverized and washed through the meshes of the strainer. The use of the lime is especially desirable in the case of the peach and plum, the foliage of which, particularly the former, is very tender and easily scalded. To the stronger foliage of the apple and most shade trees Paris green may be applied without danger at the strength of 1 pound to 150 gallons of water; with London purple it is always better to use the lime. The method of preparation of arsenate of lead has already been indicated. Lime is not needed with this arsenical.

If it be desirable to apply a fungicide at the same time, as on the apple for the codling moth and the apple scab fungus, the Bordeaux mixture^a may be used instead of water, adding the arsenical to it at the same rate per gallon as when water is used. The lime in this fungicide neutralizes any excess of free arsenic and makes it an excellent medium for the arsenical, as it removes liability of scalding the foliage and permits an application of the arsenical, if necessary, eight or ten times as strong as it could be employed with water alone.

The arsenicals can not be safely used with most other fungicides, such as the sulphate of copper, eau celeste, or iron chloride solution, the scalding effects of these being greatly intensified in the mixture.

The dry method.—The following description applies to the pole-

^a See F. B. 243, Fungicides and Their Use in Preventing Diseases of Fruits.

and-bag duster commonly used against the cotton worm: A pole 5 to 8 feet long and about 2 inches in diameter is taken, and a three-fourths-inch hole bored through it within 6 inches of each end. Near each end is securely tacked a bag of "8-ounce osnaburg cloth." 1 foot wide and 18 inches to 2 feet long, so that the powdered poison may be introduced into the bags with a funnel through the holes at the ends of the pole. The bags are filled with undiluted Paris green, which is generally preferred to London purple on account of its quicker action, and the apparatus is carried on horse or mule back, through the cotton fields, dusting two or four rows at once. The shaking induced by the motion of the animal going at a brisk walk or at a trot is sufficient to dust the plants thoroughly, or the pole may be jarred by hand. The application is preferably made in early morning or late evening, when the dew is on, to cause the poison to adhere better to the foliage.

From 1 to 2 pounds are required to the acre, and from 10 to 20 acres are covered in a day. The occurrence of heavy rains may necessitate a second application, but frequently one will suffice. This simple apparatus, on account of its effectiveness and cheapness, is employed throughout the cotton belt to the general exclusion of more complicated and expensive machinery. The cost frequently does not exceed 25 cents per acre, and the results are so satisfactory that the leaf worm is no longer considered a serious factor in cotton culture.

With the patented air-blast machines for the dry distribution of poisons, arsenicals are diluted with 10 parts of flour, lime, or ground gypsum, and from 60 to 75 acres may be covered in a day by using relays of men and teams. Greater uniformity is secured with these machines in distribution of the poisons, but their cost (from \$30 to \$60) prevents their general use.

The planter should have a good supply of poison on hand and apparatus for its application prepared in advance, since when the worm puts in an appearance its progress is very rapid, and a delay of a single day may result in material damage to the crop.

If small garden patches are dusted with poison by this or similar means from bags or with hand bellows, it is advisable always to dilute the poison with 10 parts of flour, or preferably lime, and for application to vegetables which ultimately will be used for food, as the cabbage, 1 ounce of the poison should be mixed with 6 pounds of flour or 10 of lime and dusted merely enough to show evenly over the surface. Arsenicals should not be applied to lettuce or other vegetables the free leafage of which is eaten.

Poisoned bait.—It is not always advisable or effective to apply arsenicals directly to the plants, and this is particularly true in relation to the attacks of the grasshopper and of the various cutworms

and wireworms. In such cases the use of poisoned bait has proved very satisfactory.

For grasshoppers, take 1 part, by weight, of white arsenic, 1 of sugar, or molasses, and 6 of bran, to which add water to make a wet mash. Place a tablespoonful of this at the base of each tree or vine, or apply a line of baits just ahead of the advancing army of grasshoppers, placing a tablespoonful of the mash every 6 or 8 feet and following up with another line behind the first.

A cheap grasshopper bait used successfully in parts of the West is obtained by mixing fresh horse droppings with arsenicals. One pound of Paris green, or some other convenient arsenical, together with 2 pounds of salt, are thoroughly mixed with 60 pounds of fresh horse droppings. The resulting mixture is scattered among the young "hoppers" or around the edges of fields which it is thought may be invaded. A very convenient receptacle in which to make this preparation is a half barrel. A trowel or paddle can be used in scattering the mixture in the desired places.

Bran and Paris green, on the authority of Prof. J. B. Smith, thoroughly mixed and sprinkled dry on cabbage heads, proved a most successful remedy for cabbage worms, the latter preferring the poisoned bran to the cabbage, to their prompt undoing. The same dry mixture has been successfully employed against cutworms and is recommended by Smith for the army worm, running it in rows 10 feet apart across the infested field. One pound of poison to 10 of bran is a good proportion. The bran-arsenic bait may also be used for cutworms.

For sowbugs, or pill bugs, which frequently are injurious pests to tender flowering plants and vegetables grown under frames or in glass houses, poisoned slices of potato have proved to be the most effectual remedy. The freshly sliced potato may be poisoned by dipping in a strong arsenical solution, or by dusting thickly with a dry arsenical, and should then be distributed over the beds. Pansy beds have been notably protected in this way, and a Michigan vegetable grower reports that in two nights he destroyed upward of 24,000 of these bugs by this means in four houses used for lettuce growing.

Another remedy for cutworms and also for wireworms is poisoned green succulent vegetation, such as freshly cut clover, distributed in small bunches in the infested fields. Dip the bait in a very strong arsenical solution, and protect it from drying by covering. Renew the bait as often as it becomes dry, or every three to five days.

TIME TO SPRAY FOR BITING INSECTS.

Specific directions for spraying with arsenicals to control important insect pests are given in Farmers' Bulletins or in circulars of this Bureau relating to these different insects. One of the princi-

pal uses of arsenical poisons is for the control of the codling moth. Detailed information on the subject is given in Farmers' Bulletins Nos. 247 and 283. The plum curculio is discussed in Circular No. 73, and leaf-feeding grape insects in Farmers' Bulletin No. 284. Other publications relating to special insect problems are also available giving detailed directions for spraying.

For leaf-feeding insects in general, such as the Colorado potato beetle, blister beetles, elm leaf-beetle, maple worm, and other forest or shade-tree caterpillars, the application should be made at the earliest indication of injury, and repeated as often as necessary. Fruit trees should never be sprayed when in bloom, on account of the liability of poisoning honey bees or other insects useful as cross-fertilizers.

There is no basis for the idea occasionally advanced that the frequent use of Paris green or other arsenicals on potatoes and other crops is injurious to the foliage or health of the treated plants. This matter has been fully tested, and the injurious results can always be accounted for by improper mixtures or applications.

CARE IN THE USE OF ARSENICALS.

It must be remembered that these arsenicals are very poisonous and should be so labeled. If ordinary precautions are taken, there is no danger to man or team attending their application. The wetting of either, which can not always be avoided, is not at all dangerous, on account of the great dilution of the mixture, and no ill effects whatever have resulted from this source. With some individuals the arsenate of lead, when in strong mixture, affects the eyes, but this is unusual, and, with a little care in spraying, the mist need not strike the operator at all.

The poison disappears from the plants almost completely within twenty to twenty-five days, and even if the plants were consumed shortly after the application, an impossible quantity would have to be eaten to get a poisonous dose. To illustrate, in the case of the apple, if the entire fruit were eaten, core and all, it would take several barrels at a single sitting to make a poisonous dose (Riley), and with the cabbage, dusted as recommended above, 28 heads would have to be eaten at one meal to reach this result (Gillette). It is preferable, however, to use other insecticides in the case of vegetables soon to be eaten, and thus avoid all appearance of danger.

INSECTICIDES FOR EXTERNAL SUCKING INSECTS (CONTACT POISONS).

The simple remedies for this class of insects, such as soap, insect powder, sulphur, tobacco decoction, etc., are frequently of value, but need little special explanation. Some brief notes will be given, how-

ever, describing the methods of using some of these substances which are easily available and will often be of service, particularly where few plants are to be treated. The standard remedies for this group of insects, viz, crude petroleum, kerosene, and kerosene emulsions, resin washes, lime-sulphur wash, hydrocyanic acid gas, and vapor of bisulphid of carbon, will be treated farther on.

SOAPS AS INSECTICIDES.

Any good soap is effective in destroying soft-bodied insects, such as aphides and young or soft-bodied larvæ. As winter washes in very strong solution, they furnish one of the safest and most effective means against scale insects. The soaps made of fish oil and sold under the name of whale-oil soaps are often especially valuable, but they are variable in composition and merits. A soap made with caustic potash rather than with caustic soda which is commonly used, and not containing more than 30 per cent of water, should be demanded, the potash soap yielding a liquid in dilution more readily sprayed and more effective against insects. The soda soap washes are apt to be gelatinous when cold, and difficult or impossible to spray except when kept at a very high temperature.

For aphides and delicate larvæ, such as the pear slug, a strength obtained by dissolving half a pound of soap in a gallon of water is sufficient. For the pea aphid as little as 1 pound of potash fish-oil soap to 6 gallons has been effective. Soft soap will answer as well as hard, but at least double quantity should be taken.

As a winter wash for the San Jose and allied scale insects, whale-oil or fish-oil soap is dissolved in water by boiling at the rate of 2 pounds of soap to the gallon of water. If applied hot and on a comparatively warm day in winter, it can be easily put on trees with an ordinary spray pump. On a very cold day, or with a cold solution, the mixture will clog the pump and difficulty will be experienced in getting it on the trees. Trees should be thoroughly coated with this soap wash. Pear and apple trees may be sprayed at any time during the winter. Peach and plum trees are best sprayed in the spring, shortly before the buds swell. If sprayed in midwinter or earlier, the soap solution seems to prevent the development of the fruit buds, and a loss of fruit for one year is apt to be experienced, the trees leafing out and growing, however, perhaps more vigorously on this account. The soap treatment is perfectly safe for all kinds of trees, and is very effective against the scale. With large trees, or badly infested trees, as a preliminary to treatment, it is desirable with this as well as other applications to prune them back very rigorously. This results in an economy of spray and makes much more thorough and effective work possible. The soap can be secured in large quantities at from 3½

cents to 4 cents a pound, making the mixture cost, as applied to the trees, from 7 cents to 8 cents a gallon.

PYRETHRUM, OR INSECT POWDER.

This insecticide is sold under the names of Buhach, Dalmatian, and Persian insect powder, or simply insect powder, and is the ground-up flowers of the Pyrethrum plant. It acts on insects externally through their breathing pores, and is fatal to many forms both of biting and sucking insects. It is not poisonous to man or the higher animals, and hence may be used where poisons would be objectionable. Its chief value is against household pests, such as roaches, flies, and ants, and in greenhouses, conservatories, and small gardens, where the use of arsenical poisons would be inadvisable.

It is used as a dry powder, pure or mixed with flour, in which form it may be puffed about rooms or over plants. On the latter it is preferably applied in the evening, so as to be retained by the dew. To keep out mosquitoes, and also to kill them, burning the powder in a tent or room will give satisfactory results.

It may also be used as a spray at the rate of 1 ounce to 2 gallons of water, but in this case should be mixed some twenty-four hours before being applied. For immediate use, a decoction may be prepared by boiling in water from five to ten minutes.

TOBACCO DECOCTION.

A tobacco decoction sufficiently strong for aphides and other very delicate insects may be prepared from tobacco stems and other refuse tobacco by boiling at the rate of 1 pound for each 1 or 2 gallons of water, sufficient water being added to make up for that lost in boiling.

SULPHUR.

Flowers of sulphur is one of the best remedies for plant mites, such as the red spider, the six-spotted orange mite, and the rust mite of citrus fruits. It may be applied in several forms, the simplest of which is its use as a dry powder dusted over the trees with powder bellows or any broadcasting device, preferably in the early morning when the foliage is damp with dew, or immediately after a rain. For the rust mite in very moist climates, such as that of Florida, to keep the fruit bright it is sufficient merely to sprinkle the sulphur about under the trees. The flowers of sulphur may be easily applied also with any other insecticide, such as kerosene emulsion, resin wash, or a soap wash, mixing it up first into a paste and then adding it to the spray tank at a rate of from 1 to 2 pounds to 50 gallons.

Somewhat more uniform results can be obtained perhaps by getting the sulphur into solution, either dissolving it with lye or by boiling it with lime.

In making the lye-sulphur wash, first mix 20 pounds of flowers of sulphur into a paste with cold water, then add 10 pounds of pulverized caustic soda (98 per cent). The dissolving lye will boil and liquefy the sulphur. Water must be added from time to time to prevent burning, until a concentrated solution of 20 gallons is obtained. Two gallons of this is sufficient for 50 gallons of spray, giving a strength of 2 pounds of sulphur and 1 of lye to 50 gallons of water. An even stronger application can be made without danger to the foliage. This mixture can also be used in combination with other insecticides.

The chemical combination of sulphur and lime known as sulphid of lime is perhaps a better liquid sulphur solution than the last as a remedy for mites. It may be very cheaply prepared by boiling together for an hour or more, in a small quantity of water, equal parts of flowers of sulphur and stone lime. A convenient quantity is prepared by taking 5 pounds of sulphur and 5 of lime and boiling in 3 or 4 gallons of water until the ingredients combine, forming a brownish liquid. This may be diluted to make 100 gallons of spray.

Almost any of the insecticides with which the sulphur may be applied will kill the leaf or rust mites, but the advantage of the sulphur arises from the fact that it forms an adhering coating on the leaves and kills the young mites coming from the eggs, which are very resistant to the action of insecticides.

A strongly intrenched popular fallacy, often exposed but constantly being revived, is that sulphur is a valuable remedy against insects when put into holes bored into the trunks of trees, the idea being that the sulphur, when plugged in, is carried up by the movement of the sap into the branches and distributed in the foliage, rendering the latter distasteful to insects. In point of fact, the sulphur remains exactly where it is placed, and is of no possible advantage from an insecticide standpoint or any other, and furthermore the treatment is mischievous in that it injures to that extent the soundness of the trunk.

PETROLEUM OILS.

The emulsions of kerosene, or coal oil, with soap or milk have long been the standard insecticides for external sucking insects, and especially the aphides and scale insects, and these emulsions still are the safest and most reliable means of getting these oils upon plants. The use of kerosene in the pure state as an insecticide was early experimented with by Comstock and Hubbard, and the feasibility of such applications was demonstrated, but the greater safety in the use of the emulsions resulted in a discontinuance of the use of the pure oils. Especially during the last twelve years, however, the use of these

oils in the pure state has come into very general vogue, more particularly as winter washes for the San Jose scale and allied scale insects, the value of the crude oil being especially demonstrated by Prof. J. B. Smith. The petroleum oils may also be mechanically combined with water by means of especially adapted spray pumps.

In addition to its direct application to plants, kerosene is often used as a means of destroying insects by jarring the latter from plants into pans of water on which a little of the oil is floating, or by jarring them upon cloths or screens saturated with kerosene, preferably the crude oil. The same principle is illustrated in some of the hopper-doers, or machines for collecting grasshoppers and leaf-hoppers.

As a remedy for mosquitoes, kerosene has proved very effective. It is employed to destroy the larvæ of the mosquitoes in their favorite breeding places in small pools, still ponds, or stagnant water; and where such bodies of water are not sources of drinking supply or of value for their fish, especially in the case of temporary pools from rains, which frequently breed very disagreeable local swarms, the use of oil is strongly recommended. The kerosene is applied at the rate of 1 ounce to 15 square feet of water surface. It forms a uniform film over the surface and destroys all forms of aquatic insect life, including the larvæ of the mosquito, and also the adult females coming to the water to deposit their eggs. The application retains its efficiency for several weeks, even with the occurrence of heavy rains. A light grade of fuel oil is preferred for this purpose.

The methods of using kerosene in the pure state and as emulsions with soap and milk follow.

Pure-kerosene treatment.—This consists in spraying the trees with ordinary illuminating oil (coal oil or kerosene). The application is made at any time during the winter, preferably in the latter part, and by means of a spray pump making a fine mist spray. The application should be made with the greatest care, merely enough spray being put on the plant to moisten the trunk and branches without causing the oil to flow down the trunk and collect about the base. With the use of this substance it must be constantly borne in mind that careless or excessive application of the oil will be very apt to kill the treated plant. The application should be made on a bright, dry day, so that the oil will evaporate as quickly as possible. On a moist, cloudy day the evaporation is slow, and injury to the plant is more apt to result. If the kerosene treatment be adopted, therefore, it must be with a full appreciation of the fact that the death of the tree may follow. This oil has been used, however, a great many times and very extensively without consequent injury of any kind. On the other hand, its careless use has frequently killed valuable trees. Its advantages are its effectiveness, its availability, and its cheapness, kerosene spreading

very rapidly and much less of it being required to wet the tree than of a soap and water spray. Pure kerosene is more apt to be injurious to peach and plum than to pear and apple trees, and the treatment of the former, as with the soap wash, should be deferred until spring, just before the buds swell. With young trees especially it is well to mound up about the trunk a few inches of earth to catch the overflow of oil, removing the oil-soaked earth immediately after treatment.

The crude-petroleum treatment.—Crude petroleum is used in exactly the same way as is the common illuminating oil referred to above. Its advantages over kerosene are that, as it contains a very large percentage of the heavy oils, it does not penetrate the bark so readily, and, on the other hand, only the light oils evaporate, leaving a coating of the heavy oils on the bark, which remains in evidence for months and prevents any young scale, which may come from the chance individuals not reached by the spray, from getting a foothold. Crude petroleum comes in a great many different forms, depending upon the locality, the grade successfully experimented with in the work of this Bureau showing 43° Baumé. Crude oil showing a lower Baumé than 43° is unsafe, and more than 45° is unnecessarily high. The lower specific gravity indicated (43°) is substantially that of the refined product, the removal of the lighter oils in refining practically offsetting the removal of the paraffin and vaseline. The same cautions and warnings apply to the crude as to the refined oil.

The oil-water treatment.—Various pump manufacturers have now placed on the market spraying machines which mechanically mix kerosene or crude petroleum with water in the act of spraying. The attempt is made to regulate the proportion of kerosene so that any desired percentage of oil can be thrown out with the water and be broken up by the nozzle into a sort of emulsion. Some of these machines, when everything is in good working order, give fairly satisfactory results, but absolute reliability is far from assured. The best outlook for good apparatus of this sort seems to be in carrying the oil and water in separate lines of hose to the nozzle, uniting them in the latter, and in maintaining an absolute equality of pressure on both the oil and the water tanks by employing compressed air as the motive force, kept up by an air pump, the air chamber communicating with both of the liquid receptacles. One or more manufacturers are now working on apparatus of this general description. A 10-per-cent-strength kerosene can be used for a summer spray on trees where the San Jose scale is multiplying rapidly and where it is not desirable to let it go unchecked until the time for the winter treatment. The winter treatment with the water-kerosene sprays may be made at a strength of 20 per cent of the oil. Applications of the oil-water spray should be attended with the same precautions as with the pure

oil, and there is even somewhat greater risk, owing to the natural tendency one has to apply the dilute mixture much more freely than the pure oil. The application should be merely enough to wet the bark and the mixture should not, to any extent at least, run down the trunk, as it is just as dangerous to the tree as the pure oil.

In the use of the oil sprays noted above, one who has not had experience with them is advised to make some careful preliminary tests to fully master the process, preferably waiting two or three weeks to determine the results before entering on the general treatment of the orchard. It is well, also, with the oil-water mixtures to test the pump from time to time, spraying into a glass jar or bottle to determine by actual measurement whether the correct percentages of oil and water are being maintained.

Kerosene emulsion (soap formula).—The kerosene-soap emulsion, following chiefly the Riley-Hubbard formula, has been one of the standard means against scale insects for twenty years. The distillate emulsion generally employed in California for spraying citrus and other trees is substantially the same thing, except that it is made with the California distillate or petroleum oil. Crude petroleum of any kind, as well as the refined product, may also be used in making this emulsion. The use of the soap emulsions against the San Jose scale in the East has not been very general, on account of the greater facility with which the pure oil or oil-water mixtures can be applied. The difficulty of obtaining uniform results with the latter has led to a return to the use of emulsions to some extent, and there can be no doubt about their superior merit when it is desired to dilute the pure oils. Emulsions may be applied at any strength with absolute confidence that there will be no variation. Where the emulsion can be prepared wholesale by steam power, its employment is attended with no difficulties. In California it is prepared by oil companies and sold at very slightly more than the cost of the oil and soap ingredients. It is made after the following formula:

Petroleum	gallons..	2
Whale-oil soap (or 1 quart soft soap)	pound..	$\frac{1}{2}$
Water (soft)	gallon..	1

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the oil. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct-discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assume the consistency of cream. Well made, the emulsion will keep indefinitely and should be diluted only as wanted for use.

In limestone regions, or where the water is very hard, some of the soap will combine with the lime or magnesia in the water, and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye, or rain water should be employed.

Kerosene emulsion (milk formula).—This formula is as follows:

Kerosene -----	gallons--	2
Milk (sour) -----	gallon--	1

Heating is unnecessary in making the milk emulsion, which otherwise is churned as in the former case. The change from a watery liquid to a thick buttery consistency, much thicker than with the soap, takes place very suddenly after three to five minutes' agitation. With sweet milk difficulty will frequently be experienced, and if the emulsion does not result in five minutes, the addition of a little vinegar will induce prompt action. It is better to prepare the milk emulsion from time to time for immediate use, unless it can be stored in quantity in air-tight jars; otherwise it will ferment and spoil after a week or two.

The distillate emulsion.—This wash was originated by Mr. F. Kahles, of Santa Barbara, Cal. It has been recommended by the California State board of horticulture and has found very general use in the citrus sections of the State. It is substantially an emulsion of crude petroleum, made in the same way as the kerosene emulsion described above, except that a greater amount of soap and only half as much oil proportionately is used. The lessened quantity of oil enables it to be made comparatively cheaply, and in spite of this reduction in the oil, the wash is, if anything, stronger than kerosene emulsion, judging from the experience of the writer with both these washes in southern California.

It is termed distillate spray, because the oil used is a crude distillate of the heavy California petroleum. The product used for preparing the emulsion should have a gravity of about 28° Baumé, and is the crude oil minus the lighter oil, or what distills over at a temperature between 250° and 350° C. In general characteristics it is very similar to lubricating oil. The emulsion, or, as it is generally known, "cream," is prepared as follows: Five gallons of 28° gravity distillate; 5 gallons of water, boiling; 1 to 1½ pounds of whale-oil soap. The soap is dissolved in hot water, the distillate added, and the whole thoroughly emulsified by means of a power pump until a rather heavy yellowish, creamy emulsion is produced. The product is very similar to, but rather darker in color than the ordinary kerosene emulsion. For use on citrus trees it is diluted with from 12 to 15 parts of water, the stronger wash for the lemon and the weaker for the orange. The "distillate cream" is commonly prepared and sold by oil companies or individuals at from 10 to 12 cents a gallon,

making the diluted mixture cost in the neighborhood of a cent a gallon.

The distillate spray has the same range of application as kerosene emulsion. In California it has been used extensively for the spraying of citrus trees, and when so used has been often charged with injury to trees and especially resulting in spotting of fruit. If this spray be applied to citrus plants in spring and summer, there is danger of the spotting and dropping of the young fruit and leaves. Where several applications may be necessary each year, gas fumigation is undoubtedly preferable. Nevertheless it has been fully demonstrated that any applications made to citrus trees during the comparatively dormant season in October and November, with a second treatment if necessary in January and February, the latter just before the flower spurs start, results in no injury.

How to use the emulsions.—During the growing period of summer, for most aphides and other soft-bodied insects, dilute the emulsion with 15 parts of water; for the red spider and other plant-mites, the same, with the addition of 1 ounce of flowers of sulphur to the gallon; for scale insects, the larger plant-bugs, larvæ, and beetles, dilute with from 7 to 10 parts of water. Apply with spray pump. The greatest dilution noted gives 4 per cent of oil and the lesser dilutions approximately 6 and 8 per cent.

For winter applications to the trunks and limbs of trees in the dormant and leafless condition to destroy scale insects, stronger mixtures may be used, even to the pure emulsion, which can not be sprayed successfully but may be applied with brush or sponge. Diluted with one or more parts of water it may be applied in spray without difficulty. The use of the pure emulsion is heroic treatment and only advisable in cases of excessive infestation.

The winter strengths recommended are the emulsion diluted with either 3, 4, or 5 parts of water, giving approximately 17, 13, and 11 per cent of oil. These dilutions are equivalent in strength to oil-water sprays containing 25, 20, and 15 per cent of oil, because relatively more of the emulsion is held by the bark. The two stronger mixtures may be used on the apple and pear and the weaker one on peach and plum.

The winter treatment may be followed in June by a use of the summer wash to destroy any young which may come from female scales escaping the stronger mixture.

Cautions regarding use of oil washes.—In the use of kerosene washes, and, in fact, of all oily washes on plants, the application should be just sufficient to wet the plant without allowing the liquid to run down the trunk and collect about the root. Usually, in the case of young trees at least, there is a cavity formed by the swaying of the tree in

the wind, and accumulation of the insecticide at this point, unless precautions be taken, may result in the death or injury of the plant. Under these conditions it may be advisable to mound up the trees before spraying and firmly pack the earth about the bases. Care should be taken in refilling the tank that no free oil is allowed to accumulate gradually in the residue left at the bottom when spraying with emulsions or oil-water mixtures.

Miscible oils.—It will be noted that the difficulty to be overcome in the use of oils is to effect their dilution to render them harmless to the plant. This dilution is effected with great accuracy by the kerosene-soap emulsions, and less accurately by the mechanical emulsions of oil and water. There have appeared during the last few years various so-called miscible oils, which readily and permanently mix with water, and can be applied with the same readiness and accuracy of strength as the emulsion of kerosene and soap. These oils have for their principal ingredient some form of petroleum rendered soluble by the addition of a percentage of vegetable oils and cut or saponified with an alkali, and they are, in fact, a sort of liquid petroleum soap. They are sold under various trade names. They have the disadvantage of costing a good deal more than the standard emulsions or the lime-sulphur wash (see p. 24), but have the great advantage of being always ready for immediate use without troublesome preparation. They can not be diluted for winter applications against scale insects with more than 10 or 15 parts of water to give good results, and there is some danger of injury to the trees if they are carelessly or excessively applied. They have, however, a very useful place, and especially as furnishing a good insecticide where only a few trees are to be treated and the owner would probably not go to the trouble of preparing an emulsion or the lime-sulphur wash. They have been so far principally used against the San Jose scale as dormant tree washes.

THE RESIN WASH.

The resin wash has proved of greatest value in California, particularly against the red scale (*Chrysomphalus aurantii* Mask.) and the black scale (*Saissetia oleæ* Bern.) on citrus plants, and the last named and the San Jose scale (*Aspidiotus perniciosus* Comst.) on deciduous plants, and will be of use in all similar climates where the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and where, owing to the warmth, the multiplication of the scale insects continues almost without interruption throughout the year. Where rains are liable to occur at short intervals, and in the Northern States, the quicker-acting and stronger kerosene washes and heavy soap applications are

preferable. The resin wash acts by contact, having a certain caustic effect, but principally by forming an impervious, smothering coating over the scale insects. The application may be more liberal than with the kerosene washes, the object being to wet the bark thoroughly.

The wash may be made as follows:

Resin	pounds..	20
Crude caustic soda (78 per cent)	do.....	5
Fish oil	pints..	2½
Water to make	gallons..	100

Ordinary commercial resin is used, and the caustic soda is that put up for soap establishments, in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (98 per cent) may be used—3½ pounds of the latter being the equivalent of 5 pounds of the crude. Place these substances, with the oil, in a kettle with water to cover them to a depth of 3 or 4 inches. Boil about two hours, making occasional additions of water, or until the compound resembles very strong black coffee. Dilute to one-third the final bulk with hot water, or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed the mixture should be perfectly fluid, without sediment, and should any appear in the stock mixture reheating should be resorted to; in fact the wash is preferably applied hot.

As a winter wash for scale insects, and particularly for the more resistant San Jose scale (*Aspidiotus perniciosus*), stronger washes are necessary. In southern California, for this insect, a dilution one-third less, or water to make 66⅔ gallons instead of 100 (see formula), has given good results. In Maryland, with this insect, it has proved necessary to use the wash at six times the summer strength to destroy all of the well-protected hibernating scales; and with other scale insects much stronger mixtures than those used in California have proved ineffectual in the East. For regions, therefore, with moderately severe winters the use of the resin wash to destroy hibernating scale insects seems inadvisable.

THE LIME-SULPHUR WASH.

In California, where the San Jose scale first appeared, the standard remedy for it is the lime-sulphur-salt wash, a mixture formerly used as a sheep dip in Australia and employed with little change against the San Jose scale. This wash was naturally first thought of on the discovery of the San Jose scale in eastern orchards. The earlier tests, however, conducted by this office in 1894, gave unfavorable results, and the experimentation which followed resulted in the demonstration of several distinct and valuable methods of control noted below.

Later studies of the action of this wash in California led the writer in 1900 to give it a further careful trial in the East, with most successful results, demonstrating that, with favoring conditions, i. e., absence of dashing rains for a few days after the application, it would give just as good results in the Eastern States as on the Pacific coast. A year later (1901-2) very elaborate tests conducted by Doctor Forbes in Illinois showed that fairly hard rains will not always invalidate spraying with this mixture. A vast amount of experience of the most practical kind since gained, contributed to by all the eastern experiment stations and by the big commercial fruit growers of the Middle and Eastern States, has fully demonstrated the practical merit of this wash and its superiority to others in point of safety to trees and in cheapness. Its disadvantages are the difficulty of preparation and the heavy wear which it entails on apparatus—objections, however, which do not offset its notable advantages, particularly for commercial orchard work or where the number of trees to be treated is sufficient to warrant the trouble of its preparation. It is, in fact, the standard spray now used in commercial orchards for the San Jose scale.

Composition and preparation.—In the matter of composition of the wash, scarcely any two experimenters agree. Salt was a part of the original composition of the sheep dip and has long been retained, with the idea that it added, perhaps, to the caustic qualities, and particularly to the adhesiveness of the wash. For the latter purpose a very small amount only, 1 or 2 pounds to the bushel of lime, need be added, following the custom in the preparation of whitewash mixtures. In practical experience, however, the salt seems to have been of very little benefit and is therefore omitted in the formula now given. The proportion of lime and sulphur is a matter of some indifference. The mixture obtained is sulphide of lime, and if an excess of lime is used it simply remains undissolved in the mixture and adds to the whitewashing character of the application. Too much lime is distinctly objectionable, however, because of the greater difficulty of spraying and harder wear on the pump and nozzles. The formula here given is substantially the one which has been hitherto recommended by this Bureau, reduced to the 45 or 50 gallon basis, or the capacity of the ordinary kerosene barrel commonly used in its preparation by the steam method.

Unslaked lime.....	pounds..	20
Flowers of sulphur.....	do.....	15
Water to make.....	gallons..	45 to 50

The flowers of sulphur, although requiring somewhat longer cooking, seems to make a better wash than ground sulphur, but the latter may be employed. Stone lime of good quality should be secured and

slaked in a small quantity of water, say one-third the full dilution. The sulphur, previously mixed up into a stiff paste, should be added at once to the slaking lime. The whole mixture should be boiled for at least one hour, either in an iron kettle over a fire out of doors or in barrels by steam. Prolonged boiling increases the percentage of the higher sulphides, but the practical end is obtained by boiling for the time indicated. In the process of making, the color changes from yellow to the clear brown of sulphide of lime, except for the excess of lime floating in it. After an hour's boiling the full quantity of cold water can be added, and the mixture should then be promptly applied in order to get its full strength before the higher sulphides are lost by cooling and crystallizing out. In transferring to the spray tank it should be passed through an iron screen or strainer, and the tank itself should be provided with an effective agitator.

Directions for use.—The wash is a winter application and can not be applied to trees in leaf. It may be applied at any time after the falling of foliage in early winter and prior to the swelling of the buds in spring. The later the application can be made the better the results, and the best period is just before the buds swell in March or April. It will probably be necessary also to make this application every year, or at least as often as the San Jose scale develops in any numbers. The wash kills the San Jose scale not only by direct caustic action, but also by leaving a limy coating on the trees, which remains in evidence until midsummer or later and kills or prevents the settling of young scale insects which may come from parents escaping the winter action.

The wear on pumps and nozzles can be kept to a minimum by carefully washing the apparatus promptly after use. The Vermorel nozzle is the best one for the wash, and additional caps may be secured to replace worn ones. The use of an air or other gas pressure pump instead of the ordinary liquid pump will save the wear of the lime on the pump. In spraying with this wash clothing is ruined, and only the oldest garments should be worn. Care should be taken also to protect the eyes to avoid unnecessary inflammation.

Range of usefulness.—This wash is distinctively the remedy for the San Jose scale and is particularly effective in applications to the smooth-barked fruit trees—such as peach, pear, and plum. In the case of the apple the terminal twigs are often covered with a fuzzy growth, more pronounced in some varieties than others, which prevents the wash from properly coating the bark. The young from scale insects which escape destruction at such points, for the reason indicated or from imperfect spraying, are driven out onto the new growth, or, in the case of fruit spurs, onto the fruit, so that a tree on which the scale has been pretty thoroughly exterminated may never-

theless present badly spotted fruit.^a In such cases the additional use of some one of the oil sprays may be necessary.

This wash is of equal value against closely allied scale pests, such as Forbes's scale and the West Indian peach scale, and late sprayings are quite effective against the scurfy scale and the oyster-shell scale.

The spring application, just before the buds swell, has been demonstrated by Prof. J. M. Aldrich to kill most of the eggs of the apple aphid, and Mr. Fred Johnson, of this Bureau, has found that it is equally effective in destroying the eggs of the pear-tree *Psylla*. It is useful against other pests which hibernate about the leaf buds of fruit trees, as, for example, the pear-leaf blister-mite and the silvery mite of the peach, and in California Mr. Clark has shown that it is an entirely satisfactory remedy for the peach twig borer (*Anarsia lineatella* Zell.).

In addition to this range of usefulness against insect pests this wash has shown itself to be a valuable fungicide, notably for the peach leaf curl, sprayed trees being practically immune from this disease, so that the cost of treatment in the case of the peach is often more than made good by the fungicidal benefit alone. Later experience indicates its usefulness also as a winter application for apple scab and possibly for other plant diseases.

TIME TO SPRAY FOR SUCKING INSECTS.

For the larger plant-bugs and the aphides, or active plant-lice, and all other sucking insects which are present on the plants injuriously for comparatively brief periods, or at most during summer only, the treatment should be immediate, and if in the form of spray on the plants, at a strength which will not injure growing vegetation.

For scale insects and some others, as the pear *Psylla*, which hibernate on the plants, two or more strengths are advised with most of the liquid insecticides recommended, the weaker for summer applications and the more concentrated as winter washes. The summer washes for scale insects are most effective against the young, and treatment should begin with the first appearance of the larvæ in the spring or any of the later broods, and should be followed at intervals of seven days with two or three additional applications. The first brood, for the majority of species in temperate regions, will appear during the first three weeks in May. Examination from time to time with a hand lens will enable one to determine when the young of any brood appear.

The winter washes may be used whenever summer treatment can not be successfully carried out, and are particularly advantageous in the case of deciduous plants with dense foliage which renders a thor-

^a See Bul. 46, Bur. Ent., p. 54.

ough wetting difficult in summer, or with scale insects which are so irregular in the time of disclosing their young that many summer treatments would be necessary to secure anywhere near complete extermination. In the winter also, with deciduous trees, very much less liquid is required, and the spraying may be much more expeditiously and thoroughly done. In the case of badly infested trees, a vigorous pruning is advisable as a preliminary to treatment.

DUSTING AND SPRAYING APPARATUS.

POWDER DISTRIBUTERS.

For the application of powders the dusting bags already described (pp. 11-12) are very satisfactory for field work. Much more expensive and more rapid

machine distributors have been devised, but these are rarely used. For garden work some of the small powder bellows and blowers are excellent. These cost from \$2 to \$8.

LIQUID SPRAYERS.

For the application of poisons in liquid form the prime essential is an apparatus which will break up the liquid into a fine mist-like spray that will coat every leaf and every other part

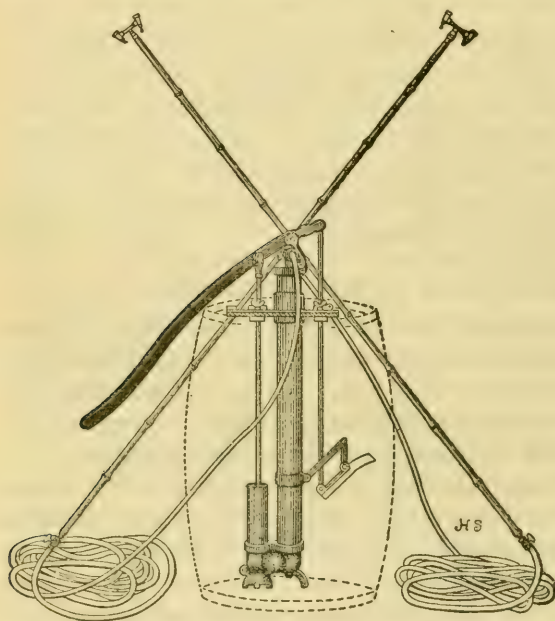


FIG. 3.—Barrel spray pump. (From Waite.)

of the plant as lightly as is compatible with thoroughness. The essential features of such an apparatus are the force pump, suitable hose, and nozzles or spray tips. The leading pump manufacturers now put out a large variety of spraying apparatus suited for all ordinary needs, including the small knapsack pumps, barrel and tank pumps, and geared and power sprayers. For limited indoor operations a hand atomizer or even a sprinkling can with fine rose tip may be made to do fair service.

The barrel pump.—This is the commonest form of spraying apparatus, and is supplied in many different styles; or, a suitable spray pump can be combined with an empty 50-gallon kerosene barrel without much difficulty. (See fig. 3.) This apparatus may be hauled about on a sled or in a wagon or a two-wheeled cart.

Tank outfits.—For larger operations it is much better to have a specially constructed rectangular or half-round spray tank of a capacity of 200 or 300 gallons. Such an apparatus enables an elevated platform to be mounted on the wagon and tank, greatly facilitating spraying of the higher parts of trees, as indicated in the accompanying illustration (fig. 4). The ideal sprayer for extensive work combines such a tank, with platform, with gasoline or steam power spray pump.



FIG. 4.—Power sprayer at work in apple orchard. (From Scott and Quaintance.)

Geared sprayers.—For low-growing regularly planted crops it is sometimes possible to use spraying apparatus which gets its power by means of a sprocket wheel from the axle of the wagon. Several types of spraying apparatus of this kind are on the market, suited especially for the treating of crops like potatoes and strawberries, and the spraying of vineyards. In orchards it is not often possible to have the wagon constantly in motion, and geared sprayers are not as a rule available.

Gas-pressure sprayers.—Some very successful spraying machines have been made which have as their motive power gas pressure. This pressure may be derived from compressed air or carbonic acid gas cylinders. It is an ideal way of applying liquid sprays, and has a

special applicability to oil-water mixtures (see p. 19). Ultimately this principle may come into much more general use.

Hose, nozzle, and agitator.—The hose and nozzle are two very essential elements of a good spraying apparatus. The very best three-eighths, one-fourth, or one-half inch 3-ply or 4-ply hose should be bought. A cheap or inferior hose will not stand the pressure and heavy wear of spraying. For orchard spraying a length of 25 feet is the least that should be used, and better 35 feet, and longer with large apparatus where it may be possible to spray more than one row at a time. Several lines of hose may be operated with a strong spray pump. Each line of hose should be supplied with an extension rod 8 or 10 feet long. This rod may be an ordinary bamboo pole into which a small brass tube is fitted carrying the nozzle, or the hose may terminate in a small gas pipe—a rather heavy device and useful for short length only.

Of the many types of nozzles which have been devised, the best is that known as the Vermorel (fig. 5). Where the power is sufficient, a double or even quadruple nozzle may be attached to each line of hose. Most of the nozzles on the market are inferior, and this special type should be insisted upon.

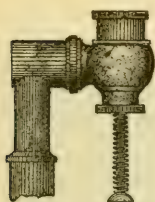


FIG. 5.—Vermorel
spray nozzle.
(From Waite.)

A very necessary feature of spray tanks is a device for keeping the liquid constantly agitated to keep up a uniform mixture or prevent the settling of the poison or solid constituents of the wash. This may be accomplished by constant stirring with a paddle.

Most of the spraying apparatus now on the market are provided with automatic agitators.

SELECTION OF SPRAYING OUTFIT.

For limited garden work or for the treatment of low plants a simple bucket pump can be used, which will cost about \$6, or the knapsack pump, costing about \$14.

For home orchards of small size a barrel pump with one line of hose will serve every purpose, the complete outfit costing \$12 to \$18.

For larger operations, with two lines of hose and nozzles, a barrel outfit, costing from \$25 to \$30, may be used.

Tank outfits, with double cylinder pumps suitable for an orchard of a thousand bearing trees, may be obtained at a cost of from \$75 to \$90.

The power sprayers are much more expensive, costing \$200 to \$300 or more.

DIRECTIONS FOR SPRAYING.

Thorough work in spraying must be done, or failure will result. To accomplish this, power sufficient to break up the liquid into a fine mist is essential. This makes it possible for the tree to be thoroughly and thinly wetted with the spray without waste, and the ideal application is to accomplish this without causing the liquid to collect in drops and fall from the tree. More of the spray is left on the leaves with a light spray than with a heavy application, which causes the globules to coalesce and a shower of drops to fall to the ground. To get a proper spray, it should be possible to produce a pressure of at least 75 pounds, or, with power outfits, of 125 to 150 pounds.

Fruit trees of average size or, if apple, such as would produce 10 or 15 bushels of fruit, will require from 3 to 7 gallons of spray to wet them thoroughly. For smaller trees, such as plum and cherry, 1 gallon to the tree may be sufficient. In spraying orchard trees and other fruit trees it will often be found convenient, especially with a smaller apparatus, to spray on each side half of each tree in a row at a time, and finish on the return.

A light rain will remove comparatively little of the poison, but a dashing rain may necessitate a renewal of the application.

HYDROCYANIC-ACID GAS TREATMENT.

The use of hydrocyanic-acid gas originated in southern California in work against citrus scale insects, and was perfected by a long period of experimentation by an agent of this Bureau, Mr. D. W. Coquillett. It is undoubtedly the most thorough method known of destroying scale insects and especially is it the best treatment for citrus trees, the abundance of foliage and nature of growth of which render thorough spraying difficult, but, on the other hand, enable the comparatively heavy tents employed in fumigation to be thrown or drawn over the trees rapidly without danger of breaking the limbs. One good gassing is usually the equivalent of two or three sprayings, the gas penetrating to every particle of the surface of the tree and often effecting an almost complete extermination, rendering another treatment unnecessary for two years or more. (See fig. 6.)

The gas treatment is just as effective against scale insects on deciduous orchard fruit trees, as has been demonstrated by a good deal of work done in the East, notably in Maryland by Professor Johnson; but the difficulty and expense of the treatment as compared with the value of the crop protected makes it as a rule prohibitive in the case of deciduous fruits. This does not apply, however, to nursery stock, which may be brought together compactly and treated in mass in

fumigating rooms or houses. The general spread of the San Jose scale in the East has made such fumigation of nursery stock, even when infestation is not shown or suspected, a necessary procedure before shipment or sale, to give the utmost assurance of safety to the purchaser. Similarly this gas is the principal agency employed in disinfecting plant material coming from abroad, and will be the chief agency for such work wherever quarantine regulations prevail.

Another very important use for hydrocyanic-acid gas is as a means of controlling insect pests in greenhouses and cold frames. The process is a special one, however, and entails considerable variation, owing to the wide range of plants to be considered. The details of the process are given in a special publication of the Bureau of Entomology (Circular No. 37), which will be supplied to anyone interested.

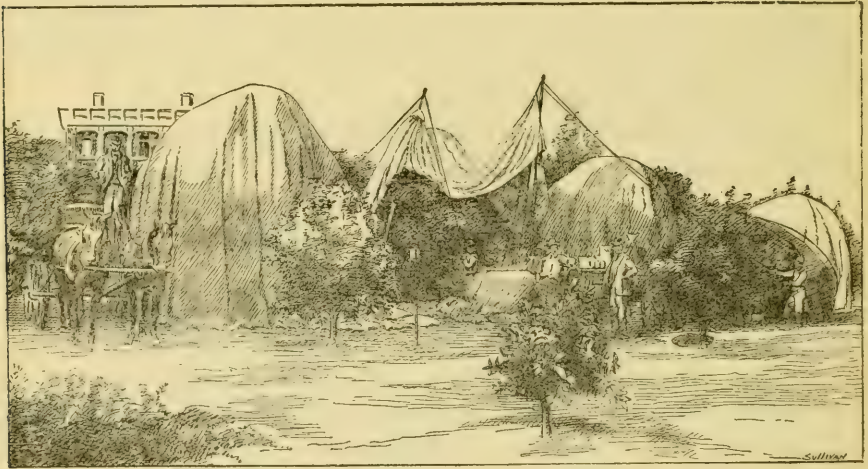


FIG. 6.—Tenting trees for gas treatment, San Diego, Cal. (Author's illustration.)

A more recent use for this gas is in disinfecting houses of insect pests and vermin. The details of this treatment are given in Circular 46, revised edition, of the Bureau of Entomology.

In all work with hydrocyanic-acid gas, its extremely poisonous nature must be constantly kept in mind and the greatest precautions must be taken to avoid inhaling it.

FUMIGATION OF NURSERY STOCK.

For the fumigation of nursery stock or imported plant material in a dormant or semidormant condition, a building or room should be provided, which can be closed practically air-tight, and it should be fitted with means of ventilation above and at the side, operated from without, so that the poisonous gas can be allowed to escape without

the necessity of anyone entering the chamber. The gas is generated by combining potassium cyanide, sulphuric acid, and water. The proportions of the chemicals are as follows: Refined potassium cyanide (98 per cent), 1 ounce; commercial sulphuric acid, 1 ounce; water, 3 fluid ounces to every hundred cubic feet of space in the fumigating room. For comparatively green or tender material the same amounts may be used to 150 cubic feet of space.

The generator of the gas may be any glazed earthenware vessel of 1 or 2 gallons capacity and should be placed on the floor of the fumigating room, and the water and acid necessary to generate the gas added to it in the order named. The cyanide should be added last, preferably in lumps the size of a walnut, and the premises promptly vacated and the door made fast. Treatment should continue forty minutes.

ORCHARD FUMIGATION.

The methods of fumigating citrus stock in California are now (1908) being given a thorough investigation by this Bureau. As already noted, the gas process has been a leading method in California for more than twenty years, but the results, while normally good, have not always been satisfactory. The object of the investigation now under way is to thoroughly standardize the process; in other words, (1) to determine the proper strength to be used for the different scale pests under different climatic conditions, and also under the different seasonal conditions of the tree; (2) to determine the physiological effect, if any, on the tree and fruit; and (3) to perfect the mechanical means of handling tents and generating the gas, and determine the proper quantity and quality of chemicals to use. The results of this investigation will be the basis of a special report on gas fumigation, and will probably modify somewhat the directions given below, which are reproduced from the previous edition of this bulletin.

The fumigation for the white fly in Florida is a special problem and has been under investigation by this Bureau for two years. The results of this investigation, including general directions for fumigation, will be given in Bulletin No. 76.

Amounts of chemicals to use.—The amounts of chemicals used vary with the size of the tree and, as now employed in California, are considerably in excess of the amounts recommended as recently as 1898. The gas treatment was first chiefly used against the black scale and at a season of the year when these scales were all in a young stage and easily killed. The effort is now made not only to kill the black scale, but also the red and purple scales, and to do more effective work than formerly against the black scale. The amounts of chemicals ordinarily advised and commonly employed in Los Angeles,

Orange, and some other counties in southern California are indicated in the subjoined table, published by the horticultural commissioners of Riverside County, Cal.

TABLE 1.—*Amounts of chemicals and water ordinarily used for trees of different sizes.*

Height of tree.	Diameter of tree.	Water.	Cyanide, O. P., 98 per cent.	Sulphuric acid, 66 per cent.
<i>Feet.</i>	<i>Feet.</i>	<i>Ounces.</i>	<i>Ounces.</i>	<i>Ounces.</i>
6	4	2	1	1
8	6	3	1½	1½
10	8	5	2½	2½
12	14	11	5	5½
16	16	17	8	9
20	16-20	22	10	12
20-24	18-22	30	14	16
24-30	20-28	34	16	18
30-36	25-30	52	24	28

The proportions here recommended are thoroughly effective for the black scale at the proper season, and measurably effective also for the California red scale and the purple scale. Where the treatment is designed to be one of extermination for these latter scale pests, from one-third to one-half more of cyanide and acid is employed, as indicated by the subjoined table, furnished by Mr. G. Havens, of Riverside. The amounts here recommended may be employed also for compact trees with dense foliage or in moist coast regions where stronger doses are needed.

TABLE 2.—*Excessive amounts of chemicals used for absolute extermination of scale insects.^a*

Height of tree.	Diameter through foliage.	Water.	Sulphuric acid.	Cyanide.	Time to leave tent on tree.
<i>Feet.</i>	<i>Feet.</i>	<i>Fluid ozs.</i>	<i>Fluid ozs.</i>	<i>Ounces.</i>	<i>Minutes.</i>
6	3-4	3	1½	¾-1	20
8	5-6	6	2½	2	30
10	7-10	15	5-6	4-5	35-40
12	9-12	20-30	7-9	5½-7½	40
14	12-14	30-35	9-12	8-10	40
16	12-15	35-40	12-14	10-12	40
18	14-16	45-55	15-18	12-15	40-50
20	16-18	60-70	20-22	16-20	45-50
22	16-18	70-75	22-25	20	50
24	18-20	75-80	25-30	22-26	50
27	20-24	85-100	30-36	28-32	60
30	20-28	100-110	36-44	32-38	60

^aA fumigation of the orangery of the Department, December 3, 1900, demonstrated that 0.15 of a gram of cyanide to the cubic foot, or a little more than half an ounce to the hundred cubic feet, is completely exterminative of scale insects, effectually killing the eggs, even of the black, purple, and other scales. The strength mentioned is that ordinarily recommended for violet houses, and the results are scarcely comparable to the proportions recommended in Tables 1 and 2, for the reason that in these tables the amount of cyanide is greatly lessened with larger trees, and, furthermore, that the orangery probably retained the gas more effectually than would be the case with cloth tents. Nevertheless, it is interesting to know that a comparatively inconsiderable strength of cyanide, when applied under the best conditions, will prove thoroughly effective against the eggs as well as the insects in all stages.

The duration of the treatment indicated in the second table varies with the size of the tree, but in general at least forty minutes should be allowed.

In Florida fumigation for the white fly can be successfully practiced only during the short period in winter when the insect does not occur in the winged stage. This period covers from two and a half to three months, namely, December, January, and February, varying with the climatic conditions of different years. This is the dry season for Florida, and the trees are in a dormant condition, with the leafage well matured and hardened, and it is possible to apply a greater strength than would be safe under California conditions. The strength recommended is approximately the same as for deciduous nursery stock, viz, 1 ounce of cyanide to 100-115 cubic feet of space, with a duration of 40 minutes.

General directions.—In the fumigation of growing stock, citrus or other, the treatment consists in inclosing the tree with a tent and filling the latter with poisonous fumes generated in the same way as described for nursery stock except that less of the chemicals is used. The treatment is made at night for trees in foliage, which includes all work in citrus orchards, to avoid the much greater likelihood of injury to tender foliage in the sunlight. The vessels for setting off the charges of cyanide and acid may be, for small doses, any ordinary earthenware jars. For large trees requiring heavy doses, tall wooden pails have proved more satisfactory, two generators being employed for the very largest trees.

It is important that the water be put in the vessel first, then the acid, and lastly the cyanide. If the water and cyanide are put in the vessel first and the acid poured in afterwards, there is danger of an explosion which will scatter the acid and burn the tents and the operator. In the spring, when the trees are tender with new growth, and in early fall when the oranges are nearly grown and the skins are likely to be easily marred, and also with young trees, it is advisable to add one-third more water than ordinarily used, or to add the cyanide in larger lumps. This causes the gas to generate more slowly and with less heat, and, if the tents are left over the trees a third longer, the effectiveness of the treatment will not be lessened. The person handling the chemicals should always have an attendant with a lantern, to hold up the tent and enable the cyanide to be quickly dropped into the generator, and to facilitate the prompt exit of the operator.

Trees are fumigated for the black scale in southern California in October, or preferably in November. The red and other scales may be treated with gas at any time, but preferably at the season already indicated. In California most of the work is done by contract, or

under the direct supervision of the county horticultural commissioners, in some cases the tents and material being furnished at a merely nominal charge, together with one experienced man to superintend the work, while a crew of four men operate the tents, the wages of the director and men being paid by the owner of the trees.

Construction and handling of tents.—The tents now employed are of

two kinds, the “sheet” tent of octagonal shape for large trees, and the “ring” tent for trees under 12 feet in height. The ring tents, or, as they are also called, the bell tents, are bell-shaped and have a hoop of half-inch gas pipe fastened within a foot or so of the opening. Two men can easily throw one of these tents over a small tree. An equipment of 36 or 40 ring tents can be handled by four men. They are rapidly thrown over the trees by the crew, and the director follows closely and introduces the chemicals. By the time the last tent has been adjusted the first one can be removed and taken across to the adjoining row. An experienced crew, with one director, can treat 350 to 400 5-year-old trees, averaging 10 feet in height, in a single night of eleven or twelve hours. The cost under such conditions averages about 8 cents a tree.

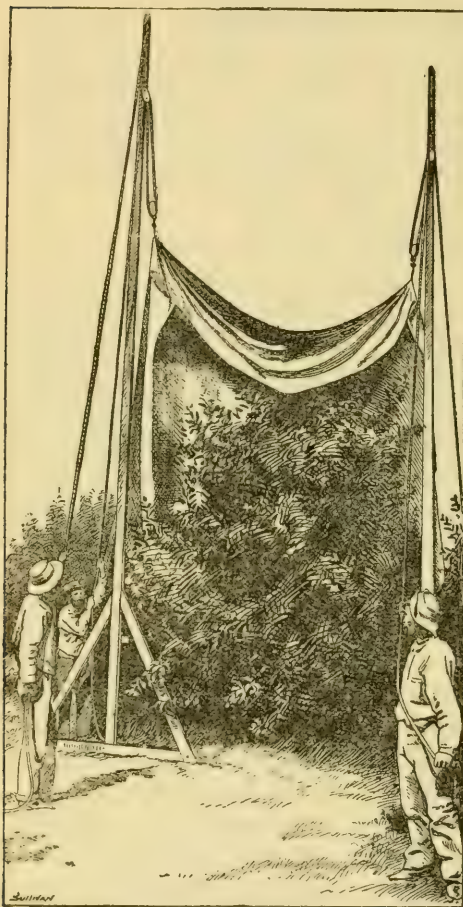


FIG. 7.—Method of hoisting sheet tent.
(After Craw.)

With large trees the large sheet tents are drawn over them by means of uprights and pulley blocks. Two of these sheets are necessary for very large trees, the first being drawn halfway over and the second drawn up and made to overlap the first. In the case of trees from 24 to 30 years old and averaging 30 feet in height, about 50 can be treated in a night of ten or twelve hours with an equipment of 12 or 15 tents, the cost being

about 75 cents per tree. It is not practicable to treat trees above 30 feet in height.

The handling of the bell tents is simple and needs no further description, but the large tents are not so easily operated, and the method of adjusting the great flat octagonal sheets over the trees, while simple enough when once understood, warrants a description. The machinery employed consists of two simple uprights, with attached blocks and tackle (fig. 7). The uprights are about 25 feet high, of strong Oregon pine, 2 by 4 inches, and are provided at the bottom with a braced crossbar to give them strength and to prevent their falling to either side while the tent is being raised. A guy rope is attached to the top of each pole and held to steady it by a member of the crew stationed at the rear of the tree. The tent is hoisted by means of two ropes 70 feet long, which pass through blocks, one fixed at the top of the pole and the other free. The tent is caught near the edge by taking a hitch around some solid object, such as a green orange, about which the cloth is gathered. By this means the tent may be caught anywhere without the trouble of reversing and turning the heavy canvas to get at rings or other fastenings attached at particular points. The two remaining members of the operating crew draw the tent up against and over one side of the tree by means of the pulley ropes sufficiently to cover the other side of the tree when the tent falls. The poles and tent together are then allowed to fall forward, leaving the tent in position. Sufficient skill is soon acquired to carry out rapidly the details of this operation, so that little time is lost in transferring the tents from tree to tree, even when the trees approximate the limit in height. A single pair of hoisting poles answers for all the tents used.

Some of the tents employed are of great size, one described by Mr. Havens having a diameter of 76 feet. It is constructed of a central piece 50 feet square, of 10-ounce army duck. Four triangular side pieces or flaps of 8-ounce duck, 10 feet wide in the middle, are strongly sewed to each side of the central sheet, forming an octagonal sheet 70 feet in diameter. About the whole sheet is then sewed a strip of 6-ounce duck, 1 yard wide. The tent is handled by means of ropes and pulleys. A 1½-inch manila rope is sewed about the border of the central piece in an octagonal pattern. Rings are attached to this rope at each of the eight corners thus formed, and also on either side of the tent. To these rings the pulley ropes are fastened, and the tent is elevated over the trees and handled very much as indicated in fig 7.

The canvas for the tents, blue or brown drilling or 8 to 10 ounce duck, may be rendered comparatively impervious to the gas by painting lightly with boiled linseed oil. This has the objection, however, of stiffening the fabric and adding considerably to its weight; it also frequently leads to its burning by spontaneous combustion unless carefully watched until the oil is dry. A much better material

than oil is found in a product obtained from the leaves of the common prickly pear cactus (*Opuntia engelmanni*), which grows in abundance in the Southwest. The liquor is obtained by soaking chopped-up leaves in water for twenty-four hours. It is given body and color by the addition of glue and yellow ocher or venetian red, and is applied to both sides of the canvas and rubbed well into the fiber of the cloth with a brush.

Some practical experience is necessary to fumigate successfully, and it will therefore rarely be wise for anyone to undertake it on a large scale without having made preliminary experiments.

BISULPHID OF CARBON VAPOR.

In line with the use of hydrocyanic-acid gas is the employment of the vapor of bisulphid of carbon to destroy insects on low-growing plants, such as the aphides on melon and squash vines. The treatment, as successfully practiced by Professors Garman and Smith, consists in covering the young vines with small tight boxes 12 to 18 inches in diameter, of either wood or paper, and introducing under each box a saucer containing one or two teaspoonfuls (1 or 2 drams) of the very volatile liquid bisulphid of carbon. The vines of older plants may be wrapped about the hill and gathered in under larger boxes or tubs, and a greater, but proportional, amount of the liquid used. The covering should be left over the plants from three-quarters of an hour to an hour, and with 50 to 100 boxes a field may be treated with comparative rapidity.

Bisulphid of carbon has proved also to be the most effective means of disinfecting grape cuttings suspected of being infested with phylloxera.^a The cuttings are inclosed in a tight barrel or fumigating box, and the bisulphid of carbon, poured out in a shallow dish, is put on top of the cuttings. An ordinary saucerful of the chemical is enough for a box 3 feet cube. The treatment lasts from forty-five to ninety minutes. This is a pretty strong fumigation, but the dormant condition of the cuttings makes this possible.

REMEDIES FOR SUBTERRANEAN INSECTS.

Almost entire dependence is placed on the caustic washes, or those that act externally, for insects living beneath the soil on the roots of plants, including both sucking and biting insects, prominent among which are the white grubs, maggots in roots of cabbage, radishes, onions, etc., cutworms, wireworms, apple and peach root-aphides, the grape phylloxera, and many others.

The insecticide must be one that will go into solution and be carried down by water. Of this sort are the kerosene emulsions and resin

^a Bul. 192. Cal. Agr. Exp. Sta., 1907.

wash—the former preferable—the potash fertilizers, muriate and kainit, and bisulphid of carbon. The simple remedies are applications of strong soap or tobacco washes to the soil about the crown; or soot, ashes, or tobacco dust buried about the roots; also similarly employed are lime and gas lime. Submersion, wherever the practice of irrigation or the natural conditions make it feasible, has proved of the greatest service against the phyloxera.

HOT WATER.

As a means of destroying root-aphides, and particularly the woolly aphid of the apple, the most generally recommended measure hitherto is the use of hot water, and this, while being both simple and inexpensive, is thoroughly effective, as has been demonstrated by practical experience. Water at nearly the boiling point may be applied about the base of young trees without the slightest danger of injury to the trees, and should be used in sufficient quantity to wet the soil thoroughly to a depth of several inches, as the aphides may penetrate nearly a foot below the surface. To facilitate the wetting of the roots and the extermination of the aphides, as much of the surface soil as possible should be first removed.

By a hot-water bath slightly infested stock can be easily freed of the aphides at the time of its removal from the nursery rows. The soil should be dislodged and the roots pruned, and in batches of a dozen or so the roots and lower portion of the trunks should be immersed for a few seconds in water kept at a temperature of 130° to 150° F. A strong soap solution similarly heated or a fifteen times diluted kerosene emulsion will give somewhat greater penetration and be more effective, although the water alone at the temperature named should destroy the aphides.

Badly infested nursery stock should be destroyed, since it would be worth little even with the aphides removed.

TOBACCO DUST.

Some very successful experiments conducted by Prof. J. M. Stedman demonstrated the very satisfactory protective, as well as remedial value of finely ground tobacco dust against the woolly aphid. The desirability of excluding the aphid altogether from nursery stock is at once apparent, and this Professor Stedman shows to be possible by placing tobacco dust freely in the trenches in which the seedlings or grafts are planted and in the orchard excavations for young trees. Nursery stock may be continuously protected by laying each spring a line of the dust in a small furrow on either side of the row and as close as possible to the tree, and covering loosely with earth. For large trees, both for protection and the destruction of existing aphides, from 2 to 5 pounds of the dust should be distributed from the base outward to a distance of 2 feet, first removing the surface

soil to a depth of from 4 to 6 inches. The tobacco kills the aphides by leaching through the soil, and acts for a year or so as a bar to reinfestation. The dust is a waste product of tobacco factories, costs about 1 cent per pound, and possesses the additional value of being worth fully its cost as a fertilizer.

Since its early recommendation marked success has been reported from the use of tobacco dust. A notable instance is that given by Mr. M. B. Waite, of the Bureau of Plant Industry, who applied a ton of tobacco waste, costing \$25, in his orchard, with the result of entirely renewing the vigor of his trees and producing a strong stubby growth of twigs. A peck of tobacco dust was placed about each of his larger trees in a circle of 2 or 3 feet around the trunk, and a slightly smaller amount about trees from one to three years old.

KEROSENE EMULSION AND RESIN WASH.

Either the kerosene-and-soap emulsion or the resin wash, the former diluted fifteen times and the latter at the strength of the winter mixture, are used to saturate the soil about the affected plants and either left to be carried down by the action of rains or washed down to greater depths by subsequent waterings.

For the grape phylloxera or the root-aphis of the peach or apple, make excavations 2 or 3 feet in diameter and 6 inches deep about the base of the plant and pour in 5 gallons of the wash. If not a rainy season, a few hours later wash down with 5 gallons of water and repeat with a like amount the day following. It is better, however, to make this treatment in the spring, when the more frequent rains will take the place of the waterings.

For root-maggots enough of the wash is put at the base of the plant to wet the soil to a depth of 1 to 2 inches, preferably followed after an hour with a like amount of water.

For white grubs in strawberry beds or in lawns the surface should be wetted with kerosene emulsion to a depth of 2 or 3 inches, following with copious waterings to be repeated for two or three days. The larvæ go to deeper and deeper levels and eventually die.

POTASH FERTILIZERS.

For white grubs, wireworms, cutworms, corn root-worms, and like insects, on the authority of Prof. J. B. Smith, either kainit or the muriate of potash—the former being the better—are broadcasted in fertilizing quantities, preferably before or during a rain, so that the material is dissolved and carried into the soil at once. These not only act to destroy the larvæ in the soil, but are deterrents, and truck lands constantly fertilized with these substances are noticeably free from attacks of insects. This, in a measure, results from the increased vigor and greater resisting power of the plants, which of itself

more than compensates for the cost of the treatment. The value of these fertilizers against the wireworms is, however, questioned by Prof. J. H. Comstock.

For the root-aphis of peach and apple, work the fertilizer into the general surface of the soil about the trees, or put it into a trench about the tree 2 feet distant from the trunk.

For cabbage and onion maggots, apply in little trenches along the rows at the rate of 300 to 500 pounds to the acre, and cover with soil.

These fertilizers (and the nitrate of soda is nearly as good) are also destructive to the various insects which enter the soil for hibernation or to undergo transformation.

BISULPHID OF CARBON.

This is the great French remedy for the phylloxera, 150,000 acres being now subjected to treatment with it, and applies equally well to all other root-inhabiting aphides. The treatment is made at any season except the period of ripening of the fruit and consists in making holes about the vines 1 foot to 16 inches deep and pouring into each about one-half ounce of the bisulphid, and closing the holes with the foot. The injections are made about $1\frac{1}{2}$ feet apart, and not closer to the vines than 1 foot. It is better to use a large number of small doses than a few large ones. Hand injectors and injecting plows are employed in France to put the bisulphid into the soil about the vines, but a short stick or iron bar may take the place of these injectors for limited tracts.

The use of bisulphid of carbon for the woolly aphis is the same as for the grape root-aphis or phylloxera. It should be applied in two or three holes about the tree to a depth of from 6 to 12 inches and not closer than $1\frac{1}{2}$ feet to the tree. An ounce of the chemical should be introduced into each hole, which should be immediately closed.

For root-maggots a teaspoonful is poured into a hole near the base of the plant, being covered as above.

For ant nests an ounce of the substance is poured into each of several holes made in the space occupied by the ants, the openings being then closed; or the action is made more rapid by covering with a wet blanket for ten minutes and then exploding the vapor at the mouth of the holes with a torch, the explosion driving the fumes more thoroughly through the soil.

SUBMERSION.

This very successful means against the phylloxera is now practiced over some 75,000 acres of vineyards in France which were once destroyed by the grape root-aphis, and the production and quality of fruit has been fully restored. In this country it will be particularly available in California and in all arid districts where irrigation is

practiced; otherwise it will be too expensive to be profitable. The best results are secured in soils in which the water will penetrate rather slowly, or from 6 to 18 inches in twenty-four hours; in loose, sandy soils it is impracticable on account of the great amount of water required. Submersion consists in keeping the soil of the vineyard flooded for from eight to twenty days after the fruit has been gathered and active growth of the vine has ceased, or during September or October, but while the phylloxera are still in active development. Early in September eight to ten days will suffice; in October fifteen to twenty days, and during the winter, forty to sixty days. Supplementing the short fall submergence a liberal July irrigation, amounting to a forty-eight hour flooding, is customary to reach any individuals surviving the fall treatment, and which in midsummer are very susceptible to the action of water.

To facilitate the operation, vineyards are commonly divided by embankments of earth into square or rectangular plats, the former for level and the latter for sloping ground, the retaining walls being protected by coverings of reed grass, etc., during the first year, or until they may be seeded to some forage plant.

This treatment will destroy many other root-attacking insects and those hibernating beneath the soil, and, in fact, is a very ancient practice in certain oriental countries bordering the Black Sea and the Grecian Archipelago.

REMEDIES FOR INSECTS AFFECTING GRAIN AND OTHER STORED PRODUCTS.

GENERAL METHODS OF TREATMENT.

The chief loss from insects of this class is to grains in farmers' bins, or grain or grain products in stores, mills, and elevators, although in the warmer latitudes much injury results from infestation in the field between the ripening of the grain and its storage in bins or granaries. Fortunately, the several important grain insects are amenable to like treatment. Aside from various important preventive operations, such as, in the South, prompt thrashing of grain after harvesting, the thorough cleansing of bins before refilling, removal of waste harboring insects from all parts of granaries and mills, and care to prevent the introduction of "weeviled" grain, there are four valuable remedial measures, viz, agitation of the grain, heating, dosing with bisulphid of carbon, and fumigating with sulphur dioxid.

The value of agitating or handling grain is well known, and whenever, as in elevators, grain can be transferred or poured from one bin into another, grain pests are not likely to trouble. The benefit will depend upon the frequency and thoroughness of the agitation. In

France machines for shaking the grain violently have been used with success. Winnowing weeviled grain is also an excellent preliminary treatment.

Raising the temperature of the grain in closed retorts or revolving cylinders to 130° to 150° F. will kill the inclosed insects if continued for three to five hours, but is apt to injure the germ, and is not advised in case of seed stock. The simplest and most effective remedies are the use of either bisulphid of carbon or sulphur dioxide.

BISULPHID OF CARBON.^a

Character and method of application.—This is a colorless liquid with very offensive odor, which, however, passes off completely in a short time. It readily volatilizes, and the vapor, which is very deadly to insect life, is heavier than air and settles and fills any compartment or bin in the top of which the liquid is placed. It may be distributed in shallow dishes or tins or in saturated waste on the top of grain in bins, and the gas will settle and permeate throughout the mass of the grain. In large bins, to hasten and equalize the operation, it is well to put a quantity of the bisulphid in the center of the grain by thrusting in balls of cotton or waste tied to a stick and saturated with the liquid, or by means of a gas pipe loosely plugged at one end, down which the liquid may be poured and the plug then loosened with a rod. Prof. H. E. Weed reports that in Mississippi the chemical is commonly poured directly onto the grain. In moderately tight bins no further precaution than to close them well need be taken, but in open bins it will be necessary to cover them over with a blanket to prevent the too rapid dissipation of the vapor. The bins or buildings should be kept closed from twenty-four to thirty-six hours, after which a thorough airing should be given them.

Limited quantities at a time may often be advantageously subjected to treatment in small bins before being placed for long storage in large masses, and especially whenever there is danger of introducing infested grain.

The bisulphid is applied at the rate of 1 pound to the ton of grain, or a pound to a cubic space 10 feet on a side.

In the case of mills, elevators, or larger granaries the application may be best made on Saturday night, leaving the building closed over Sunday, with a watchman without to see that no one enters and to guard against fire. The bisulphid should be first distributed in the upper story, working downward as rapidly as possible to avoid the settling vapor, using the substance very freely in waste or dishes at all points of infestation and over bins throughout the building. If the building be provided with an exterior means of descent (such as

^a See Farmers' Bulletin No. 145, Carbon Bisulphid as an Insecticide.

a fire escape) it would be preferable to begin with the lower story and work upward.

This insecticide may also be used in other stored products, as peas, beans, etc., and very satisfactorily where the infested material can be inclosed in a tight can, chest, or closet for treatment. It may also be employed to renovate and protect wool or similar material stored in bulk.

The bisulphid costs, in 50-pound cans, 10 cents per pound, and in small quantities, of druggists, 25 to 35 cents per pound.

Caution.—The bisulphid may be more freely employed with milling grain than with that intended for seeding, since, when used excessively, it may injure the germ. It must always be remembered that the vapor is highly inflammable and explosive, and that no fire or lighted cigars, etc., should be in the building during its use. If obtained in large quantities it should be kept in tightly closed vessels and away from fire, preferably in a small outbuilding.

While this gas is not especially dangerous to human beings, care should be taken to avoid unnecessary inhalation. It has a slight suffocating effect, and if inhaled for some time produces dizziness, which should be a warning to the operator that it is time to seek fresh, pure air.

SULPHUR DIOXID.

The fumes of burning sulphur, namely, sulphur dioxid, with some sulphur trioxid, have long been one of the standard insecticide gases for the destruction of insect pests in rooms or dwellings, and notably for the bedbug (*Cimex lectularius* L.). Doctor Stiles, of the Public Health and Marine-Hospital Service, reports very successful fumigation and disinfection of frame cottages at a seaside resort for bedbug infestation by burning sulphur at the rate of 2 pounds of stick sulphur for each 1,000 cubic feet of space. Sulphur candles for such fumigation are a standard supply material to be purchased anywhere. Sulphur fumes are also employed for disinfection from disease germs, and also in the more recent yellow-fever work for the destruction of mosquitoes in dwellings. The chief objection to the sulphur fumigation arises from the strong bleaching action of the fumes in the presence of moisture and their powerful destructive action on vegetation.

For the disinfection of ships and ships' cargoes, particularly of grain, sulphur dioxid, under the name of "Clayton gas," is now being extensively employed. To determine its efficiency and its effect on the grains treated, a considerable series of experiments was conducted by the Bureau.^a These experiments showed that sulphur dioxid, under pressure such as can be maintained in an air-tight compartment or in the hold of a ship, has great penetrating power and is very efficient as a means of destroying all kinds of insects. The germinating

^a Bul. 60, Bur. Ent., U. S. Dept. Agric., pp. 139-153. 1906.

power of seeds is quickly destroyed, but no injury results to the feeding or cooking quality of cereals. It can not be employed in the case of living plants, nor with moist fruits or products, such as apples or bananas. The best results in the case of insects infesting grains and seeds, such as *Calandra* and *Bruchus*, which are often inclosed in the seeds, were obtained by the use of a low percentage (1 to 5 per cent of gas) for a period of twelve to twenty-four hours. Employed in this way the gas is a very effective means of disinfecting stored grain or similar products not intended for planting, and has the additional advantage of entirely eliminating the danger of explosion and fire.

GENERAL CONSIDERATIONS ON THE CONTROL OF INSECTS.

ADVANTAGE OF PROMPT TREATMENT.

The importance of promptness in the treatment of plants attacked by insects can not be too strongly insisted upon. The remedy often becomes useless if long deferred, the injury having already been accomplished or gone beyond repair. If, by careful inspection of plants from time to time, the injury can be detected at the very outset, treatment is comparatively easy and the result much more satisfactory. Preventive work, therefore, should be depended on as much as possible, rather than remedial treatment later; the effort being to forestall any serious injury rather than to patch up damage which neglect has allowed to become considerable.

KILLING INSECTS AS A PROFESSION.

It may often happen that the amount of work in a community is sufficient to induce one or more persons to undertake the treatment of plants at a given charge per tree or per gallon of the insecticide employed. Where this is the case, and the contracting parties are evidently experienced and capable, it is frequently more economical in the end to employ such experienced persons, especially when a guarantee is given, rather than attempt to do the work one's self with the attending difficulty of preparing insecticides and securing apparatus for work on a comparatively small scale. In California this is a common practice, and also in some of our Eastern cities, and has worked excellently.

DETERMINATION OF THE RESULT OF TREATMENT.

It is often of importance to know when and how to determine the effect of any treatment applied directly to insects exposed on the surface of plants. In the case of scale insects, especially during the dormant condition in winter, the response to insecticides is very slow and gradual. The scale larvæ, or any young scales during the growing season, are killed in a few minutes, or a few hours at furthest, just as any other soft-bodied insect, but the mature scale does not usually

exhibit the effects of the wash or gas for some time. Little can be judged, ordinarily, of the ultimate results before two weeks, and it is often necessary to wait one or even two months to get final conclusions. In the case of liquid washes the slow progressive death of the scales is apparently due to the gradual penetration of the insecticide, and also to the softening and loosening of the scale itself, enabling subsequent weather conditions of moisture and cold to be more fatal.

With such biting insects as caterpillars and slug worms, after treatment with arsenicals or other poisons death rapidly follows, the time being somewhat in proportion to the size of the larvæ and their natural vigor. Soft-bodied larvæ, such as the slug worms and very young larvæ of moths and beetles or other insects, are killed in a day or two. Large and strong larvæ sometimes survive the effect of poison for eight or ten days, and leaf-feeding beetles will often fly away and perish from the poison in their places of concealment.

Many larvæ or other forms of leaf-feeding insects, after taking one or two meals of poisoned foliage, will remain in a semitorpid and diseased condition on the plants for several days before they finally succumb. The protection to the plant, however, is just as great as though they had died immediately, but misapprehension may often arise and the poison may be deemed to have been of no service.

The complete extermination of insects on plants is often a very difficult, if not an impossible undertaking. This is especially true of scale insects. In California even, where the work against these enemies of fruits has been most thorough and successful, experience has shown that the best that can be done is a practical elimination of the scale for the time being, and it is often necessary to repeat the treatment every year or two. In exceptional cases once in three years suffices. With leaf-feeding insects it is often possible to effect complete extermination with the use of arsenical poisons. Such sucking insects as aphides may also be completely exterminated. But in general all applications or methods of treatment must be recognized, more or less, as a continuous charge on the crop, as much so as are the ordinary cultural operations.

CONTROL OF INSECTS BY CULTURAL METHODS.

It is much easier to ward off an attack of insects or to make conditions unfavorable for their multiplication than to destroy them after they are once in possession; and in controlling them, methods and systems of farm and orchard culture have long been recognized as of the greatest value, more so even than the employment of insecticides, which, in most cases, can only stop an injury already begun. Insects thrive on neglect, multiply best in land seldom or never cultivated, and winter over in rubbish, prunings, or the undisturbed soil about their food plants, and become, under these conditions, more numerous

every year. It is a fact of common observation that it is the neglected farm, vineyard, or orchard filled with weeds or wild growth which is certain to be stocked with all the principal insect enemies; and, on the other hand, thorough and constant culture, with the removal and burning of prunings, stubble, and other waste, the collection and destruction of fallen and diseased fruit, and the practice, where possible, of fall plowing to disturb the hibernating quarters of field insects, will almost certainly be accompanied by comparative immunity from insect pests.

The vigor and healthfulness of plant growth has also much to do with freedom from insect injury. Strong, healthy plants seem to have a native power of resistance which renders them, in a measure, distasteful to most insects, or at least able to throw off or withstand their attacks. A plant already weakened from any cause, however, seems to be especially sought after, is almost sure to be the first affected, and furnishes a starting point for general infestation. Anything, therefore, which aids good culture in keeping plants strong and vigorous, such as the judicious use of fertilizers, will materially assist in preventing injury.

The constant cropping of large areas of land year after year to the same staple is largely responsible for the excessive loss from insects in this country as compared with European countries, because this practice furnishes the best possible conditions for the multiplication of the enemies of such crops. A most valuable cultural means, therefore, is a system of rotation of crops which will prevent the gradual yearly increase of the enemies of any particular staple by the substitution every year or two of other cultures not subject to the attacks of the insect enemies of the first.

With such insects as the Hessian fly, the squash borers, and many others which have regular times of appearance, much can be done by the planting of early or late varieties or by deferring seeding so as to avoid the periods of excessive danger. Wherever possible, varieties should be selected which experience has shown to be resistant to insect attack. Familiar illustrations of such resistant varieties in all classes of cultivated plants will occur to every practical man, and a better instance of the benefit to be derived from taking advantage of this knowledge can not be given than the almost universal adoption of resistant American vines as stocks for the regeneration of the vineyards of France destroyed by the phylloxera and for the similarly affected vineyards of European grapes in California.

In the case of stored-grain pests, particularly the Angoumois moth, or so-called "fly weevil," the chief danger in the South occurs while the grain is standing in shock or stack, after harvesting, during which period the insects have easy access to it. This source of infestation may be avoided by thrashing grain promptly after harvesting and storing it in bulk. This will prevent injury to more than the sur-

face layer, as the insects are not likely to penetrate deeply into the mass of the grain.

These general notes are by no means new, but their importance justifies their repetition, as indicating the best preventive measures in connection with the remedial ones already given.

THE PROFIT IN REMEDIAL MEASURES.

The overwhelming experience of the past twenty years makes it almost unnecessary to urge, on the ground of pecuniary returns, the adoption of the measures recommended in the foregoing pages against insects. To emphasize the value of such practice it is only necessary to call attention to the fact that the loss to orchard, garden, and farm crops frequently amounts to from 15 to 75 per cent of the entire product, and innumerable instances could be pointed out where such loss has been sustained year after year, while now, by the adoption of remedial measures, large yields are regularly secured with an insignificant expenditure for treatment. It has been established that in the case of the apple crop spraying will protect from 50 to 75 per cent of the fruit which would otherwise be wormy, and that in actual marketing experience the price has been enhanced from \$1 to \$2.50 per barrel, and this at a cost of only about 10 cents per tree for labor and material. This is especially true of regions where the codling moth has but one full brood annually.

In the case of one orchard in Virginia, only one-third of which was sprayed, the result was an increase in the yield of sound fruit in the portion treated of nearly 50 per cent, and an increase of the value of this fruit over the rest of 100 per cent. The loss from not having treated the other two-thirds was estimated at \$2,500. The saving to the plum crop and other small fruits frequently amounts to the securing of a perfect crop where otherwise no yield whatever of sound fruit could be secured.

An illustration in the case of field insects may also be given where, by the adoption of a system of rotation, in which oats were made to alternate with corn, the owner of a large farm in Indiana made a saving of \$10,000 per year, this amount representing the loss previously sustained annually from the corn rootworm. The cotton crop, which formerly in years of bad infestation by the leaf worm was estimated to be injured to the extent of \$30,000,000, is now comparatively free from such injury, owing to the general use of arsenicals.

Facts of like import could be adduced in regard to many other leading staples, but the foregoing are sufficient to emphasize the money value of intelligent action against insect enemies, which may often represent the difference between a profit and a loss in agricultural operations.

DIV. INSECTS.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 130.

THE MEXICAN COTTON-BOLL WEEVIL.

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1901.

LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY,

Washington, D. C., March 18, 1901.

SIR: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, the manuscript of a report on The Mexican Cotton-Boll Weevil, prepared by Prof. F. W. Mally, State Entomologist of Texas. The report deals with the methods found by him to be most practicable in destroying the pest, and which he recommends for general application. Actual tests upon large plantations are said to have proven the efficacy of the suggestions made by the author in affording relief from serious ravages by the weevil.

Very respectfully,

L. O. HOWARD,

Entomologist.

Hon. JAMES WILSON,

Secretary.

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THE MEXICAN COTTON-BOLL WEEVIL.

(*Anthrenus grandis* Boh.)

LIFE HISTORY AND HABITS.

ADULT.

Size.—The full-grown weevils (fig. 1) vary in size from three-sixteenths to three-eighths of an inch in length. They are quite active when traveling, but fly rather sluggishly. The size of the adult frequently depends upon the food supply which the larva has had. The writer has known eggs to be laid into squares no larger than a small pea, and the small white larva would feed upon the contents of this until all was consumed, and then transform into the adult weevil of not more than half the normal size. This shows the adaptability of this pest to its food supply.

Color.—The color of the adult varies somewhat, depending upon the age of the weevil examined. A newly transformed weevil is whitish all over. As it gets older the body becomes chocolate in color. The wings at first turn a clear wine color and then darker, later becoming slightly hairy or pubescent. Down the middle of the upper surface of the thorax this pubescence becomes so dense and somewhat longer that it forms a whitish line. Some adults are found whose body color is essentially black instead of a dull chocolate. Again, some are more distinctly light brown. The pubescence soon wears off somewhat and then the weevils look darker. This accounts for the frequent confusion among planters as to what the genuine weevil is and how it looks.

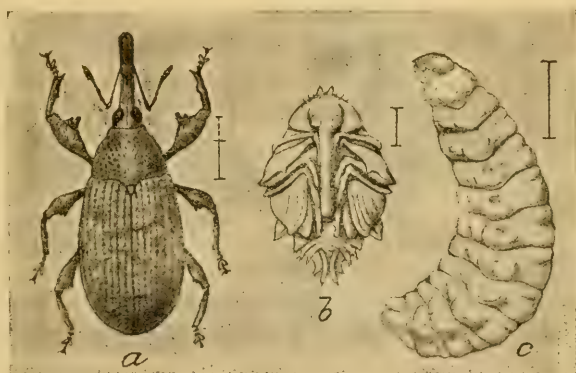


FIG. 1.—The Mexican cotton-boll weevil (*Anthrenus grandis*): a, adult beetle; b, pupa; c, larva—all enlarged. (After Howard.)

Feeding period.—The active feeding period of the adult weevils is during the day. At night they travel and fly but very little. It has often been noted that a weevil observed in any particular square at sundown, is found within the identical square at sunrise unless disturbed during the night. During the vigorous growing season of cotton the weevils go about from plant to plant by short sluggish flights. They prepare for flight by getting out upon some exposed portion of the plant and then aimlessly fly in a direct line until another plant is struck. When cotton is knee high or more it usually happens that they fly only across to the next row before striking another plant, on which they alight. Their spread over the field is a slow process during this growing period of the cotton, and the egg-laying season of the weevil.

Early in spring when the adults come out from winter quarters they are voracious eaters and feed readily on any young cotton to be found. They feed for the most part by getting up among the developing leaf buds between the seed leaves, into which they eat, just as they do the young squares later. In spring, before squares are formed on cotton, the weevils often eat a small hole into the tender growing portions of the stems or branches. They have a habit of eating into these somewhat differently than when eating into a square under cover. It should be stated, by way of explanation, that the end of the stout, slightly curved snout of the weevil is provided with small, claw-like jaws, with which it actually eats a hole rather than bores it, as the popular notion is. When preparing to feed on any exposed portions of the plant, the weevil nearly always uses its sharp mandibles at the end of the snout to rasp the outer bark, so as to enable it to get hold of the ragged ends, which it then deliberately pulls off and lays to one side. After doing this it eats the tender portions underneath. This process is comparable to peeling an apple before eating it. This is not an invariable habit, but prevails in the majority of instances, and is important as bearing upon the methods of poisoning, to be discussed later on. As soon as squares are formed on the plants the weevils at once attack them and eat holes into them from behind the shelter of the involucre or ruffle. When hard pressed for squares to eat, small, and even large, bolls will be eaten into.

Early in the spring the weevils are very active and feed freely and extensively. In the fall as the hibernating season approaches they become more sluggish and feed much more sparingly. In spring, too, when they are disturbed, they "play possum" and drop off the plant readily. In the fall they take fright less easily, are slower to "play possum," and are less active in every way.

It has not yet been definitely established that the boll weevil will feed upon any other plant than cotton.

THE EGG.

When ready to deposit an egg the female eats the customary hole into a square, form, or boll, and hollows it out somewhat larger at the inner end. She then turns around, protrudes her ovipositor, or egg guide, into this hole and deposits the egg. As she finishes this process she seals the opening with a small drop of glue. This prevents ants and other predaceous insects from finding the egg. It also prevents rain and dew from starting decay from the outside. It requires fifteen to twenty minutes for the weevil to eat the hole for the egg, deposit it, and seal the opening.

The egg is elliptical and almost colorless. It hatches in two or three days after deposition, depending upon the weather, producing a very small, white, footless larva, which immediately begins feeding inside the square.

So far as yet observed the female will deposit her eggs nowhere else than in the young squares, forms, or bolls, and never promiscuously

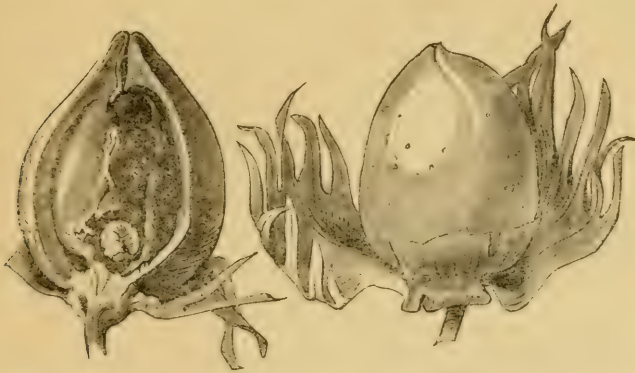


FIG. 2.—Mature boll cut open at left, showing full-grown larva; the boll at right is not cut, but shows feeding punctures and oviposition marks. (After Howard.)

over the plant. It sometimes happens that two eggs are laid into a square, but this is not common. Should squares or forms become scarce, the females attack the young, and even well-grown, bolls. When thus pressed for food it is often found that two or three, or even more, eggs are laid into the developing bolls.

Observations are not yet conclusive, but those made so far indicate that a distinct hibernating brood is produced late in the season in those sections where frost kills cotton. Few, if any, of the eggs of the females of this generation are laid in the fall. The eggs deposited late in the season are more likely, or mostly, eggs of belated females from the previous generation. If a distinct hibernating generation is not produced late in the season, the fact remains that the last brood deposits very few eggs before the end of the season during which it was bred.

THE LARVA.

The white grub-like larva hatched from the egg at once begins feeding on the tender inside portions of the square, form, or boll into which the egg has been laid. It feeds here for its entire life period, protected from all exposure. In full-grown bolls these larvæ are

often found feeding inside the maturing seeds. The egg is occasionally deposited so late in the season that the larva barely has time to eat into the seed before the boll opens. Hence the cotton is sometimes gathered and ginned before the larva has become full grown, passed through the pupal stage, and issued as a weevil. It consequently often happens that adult weevils are found in the seeds later on. (See figs. 2 and 3.)



FIG. 3.—*a*, Newly hatched larva in young square; *b*, nearly full-grown larva *in situ*; *c*, pupa in young boll picked from the ground. (After Howard.)

It requires fourteen to seventeen days from the time of hatching for the larva to become full grown. It is a white footless grub, with a brown head. When full grown it is from a quarter to three-eighths of an inch in length, usually slightly curved or doubled upon itself.

THE PUPA.

When the larva is full fed it passes into the third or pupal stage. Here it transforms into a robust, short, compact form, showing the wing pads, legs, and snout. The abdominal end is free and is wriggled about very actively when disturbed. It is white until just a short time before the weevil is ready to come out of this pupal transformation state. Then it turns darker and the weevil escapes or hatches. The time occupied in this stage is seven to ten days. After the weevil leaves the pupal skin it requires a couple of days to color and harden up and to appear, as does the adult weevil already described under that heading. When fully colored up, the adult eats a small round hole out of the square or boll it has been in all its lifetime, and escapes to the open air.

It should be carefully noted that the egg is laid nowhere else than in the squares, forms, or bolls. The larva grows and matures inside these, and there changes into the third or pupal stage. This stage is also passed in the same squares, as also the first few days of the adult stage. This is important, as will be noted from the recommendations based upon it further on in this report.

HIBERNATION.

The adult weevils begin seeking winter quarters as soon as the first cold weather begins in the fall. They crawl into cracks and crevices under bark of posts and trees, and under all kinds of trash and rubbish on the farm, in the gin, seed houses, and buildings on the plantation. The partially opened bolls and cotton-stalk trash also afford hiding and shelter. The weevils therefore pass the winter in the adult stage, ready to come out in spring as soon as cotton planting begins. They come out as soon as the weather becomes warm enough, and from that time on until frost they are depredating on cotton.

There are often many eggs, larvæ, and pupæ in the squares and bolls when the first heavy frosts come. These all die from the effects of severe cold before spring. In fact, severe freezes alternating with warm spells will kill many of the full-grown hibernating weevils before spring. Only the full-grown insects have any chance of passing the winter.

MIGRATION.

There is much confusion as to the spread of this pest over new territory from year to year. Close observation concerning this problem has developed the fact that during the growing season for cotton the weevil spreads very slowly except under unusual conditions. The unprecedented high winds and storms of the season, culminating in the disastrous hurricane of September 8, 1900, which covered almost the entire weevil district, were largely responsible for the unusual spread over so much new territory in midseason that year.

As already stated, the weevils are sluggish in flight, and ordinarily fly no great distance at one time. As a matter of fact, they spread over new territory mostly in the fall, when frosts compel them to leave the cotton fields and seek winter quarters. That is to say, their hibernation march in the fall usually causes them to fly more continuously and greater distances in a few weeks than during the entire growing season.

Then, again, in spring, when warm weather brings them out, they also have a long chase in search of fields where young cotton may be found growing and ready to afford them their first food. Here, again, they spread over more territory in a few weeks than during the remainder of the growing season. Hence after the migration to new territory in fall and spring there is very little more spread unless there should be a scarcity of food.

It is important to note these facts carefully, because many planters fail to make war on the weevil for the reason, as they assert, that the weevil will spread to them from their neighbors who make no effort to subdue the pest. This idea is of course erroneous, in view of the fact that during the growing season there is little spread after the

hibernating weevils have all issued. Each planter will therefore receive practically the full benefit of all efforts made to control the pest whether his neighbors do so or not; but practically the same fight will have to be made each season, whereas if all cooperated, the pest would gradually, but certainly, be so reduced that the expense of making war on it would be lowered to a minimum.

DISTINCTION BETWEEN BOLL WEEVILS AND ACORN WEEVILS AND SHARPSHOOTERS.

The opinion is often expressed that the acorn weevil, so common in oak-timber sections, is identical with the boll weevil. Nothing could be a more pronounced error. The two are positively distinct species. The boll weevil will not attack acorns, nor does the acorn weevil attack cotton for food. The boll weevil flies sparingly at night, nor is it attracted to lights, while the acorn weevil flies freely at night at certain seasons and is readily attracted to lights. Failure to know and observe these differences accounts for the assertion made by some otherwise conscientious and reliable persons that boll weevils were caught by lamps. In all cases investigated, weevils so caught proved to be of the acorn and other species, not boll weevils.

Then, again, many assert that the sharpshooter is identical with the weevil under discussion. As a matter of fact, the insect properly called the sharpshooter is not even a weevil, but a leaf hopper, and feeds by puncturing and not by biting. Attention is called to these popular errors for the reason that some refrain from making war on the boll weevil because nothing is done against either of the other two insects mentioned.

EXTERMINATION OF WEEVIL BY CULTURAL METHODS.

Various methods have been practiced for the destruction of the Mexican boll weevil and for the treatment of infested cotton fields. Reference will here be made to the remedies found most efficacious by the writer as the result of his special investigation of the subject during the last two years, which it is hoped may be useful to the very large number of persons interested in the cotton industry.

LAMP TRAPPING.

The adult boll weevil flies little, if any, at night, and hence lamps will trap very few, if any, of them. Numerous tests have been made with specially designed lamps, which were so placed in infested fields that plants having squares with weevils resting quietly in them might be in the direct glare and light of the lamp. In no case did the light coax out the weevil from its quiet rest. This practice is entirely useless, and the time, labor, and money so expended are totally lost.

On the other hand, these lamps attract many beneficial insects, which aid us in destroying the harmful ones, and many hundreds of the former are trapped and destroyed. Thus, instead of being a benefit, this lamp trapping is a positive injury, and can not be too strongly condemned.

TRAP ROWS OF COTTON.

It was often noted that one field of cotton was badly infested, while one or more adjoining fields remained free for a long period. This fact emphasizes the statement previously made that the weevil spreads slowly to new territory once it finds growing cotton to feed upon. It further argues the advisability of everyone's fighting the pest regardless of what his neighbor does. Investigation established the fact that the fields infested with weevils so long in advance of the adjoining fields were the earliest planted and the first to offer food for the weevils emerging from their winter quarters and taking up the search for young cotton. In other words, this first cotton formed centers of attraction and concentration for the weevils as they appeared. The neighbors who planted later escaped the early attacks.

This suggested the advisability of testing the method of planting a few rows of cotton extra early, and of an early maturing kind, so as to uniformly trap the emerging hibernating weevils as they came to the fields. These few early rows planted some time ahead of the main crop serve to concentrate the pest on them. By treating them and making war on the pest on these few rows the work is not only more effective, but the labor and cost are also immensely reduced. Accordingly, in a number of instances trap rows were planted on plantations in the manner indicated to test the value of this method. The results exceeded expectations. The trap rows were the first to produce squares for the weevils, which quite uniformly confined their first attack and egg laying to these rows for some time after the main crop, which was planted much later, was up and growing nicely.

Just how long the planting of the main crop should be delayed after the trap rows are well started depends largely upon weather and local conditions. Each planter must manage that to suit his locality. The special point to be observed is to plant the trap rows as early as may be and give them as great a start of the main crop as is possible. Generally speaking, make sure that the trap rows are attracting the weevils before the rest of the crop is planted.

In answer to the question, Why not plant the entire crop early? it may be stated that there is no objection except that it makes a trap of the whole plantation and multiplies the expense of destroying the pest over the whole field, whereas the first early warfare against the pest might be confined to the trap rows.

The question may properly be asked, Where should the trap rows be planted? According to my observation, the first boll weevils in

spring are usually found about gins and seed houses. Hence it will be advisable to plant short rows of cotton near these places; also about houses, feed lots, and stock sheds, especially if the cattle have been fed freely on cotton seed. Trapping the weevils here prevents their spreading to the fields.

Timbered sections afford ample opportunities for the weevil to hide, and hence trap rows should be planted along the edges of the woods, alongside of or surrounding the cotton fields. (See fig. 4.)

For the field planting of trap rows it has been found fully satisfactory to plant a row or two across the middle of every 20 acres, or at that rate.

By giving careful attention to the location of trap rows many weevils can be congregated and destroyed before they reach the cotton fields.

Should the planting season be so unfavorable as to make it impracticable to properly employ the trap-row plan, then it will be especially

advisable to resort to picking the cotton absolutely clean of all squares as soon as it is evident that all of the hibernating weevils have issued. Then follow this immediately with a thorough spraying, using the stronger solution recommended for the trap rows. Under these circumstances the weevils will be largely gathered and destroyed. At the same time those which escape being gathered, finding no squares, will be tempted to eat of the poison more freely, which will insure the greatest possible destruction of the pest.



FIG. 4.—Late fall boll, showing how beetles hide between the boll and the covering or wrapper. (After Howard.)

Treatment and management of the trap rows.—

Once the weevils are congregated on the trap rows, advantage can be taken of their habit of “playing possum” when disturbed or frightened. To profit by this habit, tests were made of a plan to use pans, and, bending the plants over them, to shake the plants vigorously, repeating this operation from plant to plant along down the row. The pans should be previously smeared on the bottoms and along the sides with coal tar or some other adhesive substance. Much depends on the operator. Careful inspection of the rows thus treated showed that from 60 to 95 per cent of all weevils on the plants could thus be shaken off. This work carefully done, when confined to trap rows only, is entirely feasible, also economical, and very effective. This shaking method becomes impracticable if an attempt is made to apply it to large plantations. For small fields of from 5 to 15 or 20 acres there is no more certain, economical, and effective method. It should be used for the trap rows especially, and for small fields.

FLARING OF SQUARES.

Planters readily recognize when boll weevils, or some insect affecting the squares similarly, are at work. They may discover their presence by what is called "flaring." This is an opening out and spreading down from the bloom or boll of the involucre, or shuck, exposing them. Yellowing of the affected squares follows the flaring. The squares affected soon ripen, as it were, and drop to the ground. This flaring and shedding is caused by the weevils eating holes into the squares and depositing their eggs. The simple eating off of the fruiting organs will produce the same result. This shedding should not be confused with the natural shedding of cotton, or with that caused by excessive rains following drought. Later in the season, when the weevils have become extremely numerous, there is one, or perhaps two, to every square produced by the plant. The preparation to flare and drop off begins at once after injury, and in most cases the blossoms never open. For this reason the remark is often heard that the boll weevil must be in the cotton because it does not bloom. It requires from one to two weeks to complete the flaring and dropping off of the affected squares. This is an important fact for the reason, as already stated, that the development of the adult weevil takes place within the square and requires at least twenty-five to thirty days for such transformation. If, then, the shedding occurs within two weeks after egg deposition, there will remain two weeks of lying on the ground, during which the life of the weevil is at the mercy of the planter. Of course, this does not apply when the squares become so scarce that the weevils are forced to lay their eggs into the boll. These do not drop, and this fact emphasizes the argument for determined action as early as possible in spring.

GATHERING THE FALLEN SQUARES.

It has been ascertained that the female deposits her eggs nowhere else than in the squares or young bolls. The infested squares flare and shed two weeks before the hatched larvæ can mature and escape. The female is limited in her capacity to lay eggs. Hence gathering up the fallen squares resulting from her egg laying and burning them must surely destroy the entire generation. Nothing can be plainer than that if this gathering and burning were scrupulously and persistently followed from the very first in the spring, the first generation of eggs would all be destroyed and the breeding for that season would be practically stopped.

The fact that the square lies about two weeks before the weevil can mature and escape makes it clear that this gathering should be practiced at intervals of ten to twelve days. This is of extreme importance for the reason that should squares lie long enough to allow

weevils to mature the gathering will have to be continued for the period of the second generation of females and their egg laying. Properly and scrupulously followed up, there should be very few shed weevil-infested squares to gather after the hibernating weevils have finished their egg laying.

It should always be borne in mind that as the cotton gets older the plant naturally sheds more squares, even though they were not ravaged by insect pests. Hence planters should not be discouraged with their success or results simply because squares continue to fall. The uninfested squares must be gathered at all times during the egg-laying season to make sure that no infested ones escape.

This method, as also the pan-shaking process, has often met with all kinds of ridicule, and has been dismissed by many as entirely impracticable. It is worthy of note, however, that this ridicule comes from those who have never tested the method. No one can deny the efficiency of these methods, and their value, therefore, hinges upon whether they are practicable and economical. Those planters who have only a small acreage have been the ones who during the past year have applied these methods most extensively. So far as tests among these small planters are concerned, there have been hundreds of them. The planters are all perfectly satisfied with the practical utility, economy, and effectiveness of these plans. Children can be employed to do this work of gathering. In this way many small cotton fields have been protected from the ravages of the boll weevil the past season by the industrious work of the children, and the farmer has had no perceptible extra expense.

Cost of gathering squares.—But it is the large planter who has a thousand acres under cultivation who stands aghast at the extensiveness of the task set before him. In order to secure actual figures and experience, tests were made upon these large plantations. In the trials adult negroes were employed, while as a matter of fact boys from 10 to 15 years could as well have been utilized. By actual test in this way it was established beyond question that for the months of May and June every fallen square can be gathered at a cost of from 5 cents to 10 cents per acre per gathering. When older, the cotton naturally sheds more and the expense for July may reach 25 cents per acre. When boys are employed the expense can be proportionately decreased. In the actual test an adult laborer easily gathered the squares from 15 to 20 acres per day during May, and from 10 to 15 acres during June. After that time the area gathered per day decreased to from 3 to 5 acres. Hence, early in the season with a squad of ten laborers a 1,000-acre plantation can be gone over each week if necessary at an expense of \$60 per week, or 6 cents per acre. This certainly must appear economical to really thoughtful, practical minds. Many extensive planters have proven to their own satisfac-

tion the economy and practical utility of the gathering and burning process.

Furthermore, the adoption of the early trap-row strategy materially lessens the task. As heretofore stated, the adults in spring seek the early trap cotton and begin their ravages and their egg laying upon it. This confines the first gatherings of fallen squares to the few trap rows. The immense saving in labor is apparent and should appeal to every thoughtful planter.

PICKING OFF THE SQUARES.

A very effective method which can be resorted to with certainty of good results is that of actually picking off all the early squares which are produced before the cotton begins blooming. As has been noted, early in spring the weevils feed upon and among the terminal leaf buds before squares are developed. As soon, however, as these are produced the weevils take refuge in them and begin their ravages. As the squares are produced rather sparingly at first and the adults are found nowhere else, it is plain that practically the entire lot of weevils which withstood the winter may be collected and destroyed by this method, the important point being to delay this picking long enough to make sure that all living hibernating weevils have emerged. It is also important that this picking should be done early in the morning before the adults begin traveling in search of fresh squares for the day.

This method can be made especially effective upon the trap rows if they have been properly developed and managed. On these especially should it be resorted to in connection with gathering up the fallen squares, and to continue the war against the adults which escaped the pan-shaking method practiced before squares are formed.

This process involves a slight loss of squares intended for early fruiting, but the advantage gained in the greater certainty of eradicating the pest early, and the consequent immunity of the squares set subsequently, more than offset the slight possible loss involved.

PLOWING UNDER THE FALLEN SQUARES.

To avoid gathering up the fallen infested squares some planters practice plowing them under in the hope of destroying them. To ascertain the real merit of this process, specially designed cages were made, and adult weevils buried at various depths from 2 to 6 and 8 inches. The results uniformly showed that most of the weevils worked their way out from the shallow depths. This was especially true of the 2 and 3 inch depths, from which a healthy uninjured weevil rarely failed to escape. From a study of the actual cultivation and plowing operations in the open field it developed that by the ordinary sweep cultivation there could be no hope of plowing anything under to a greater depth than 2 to 3 inches. On black land soils especially will the depth

rarely be greater than 2 inches. As just noted, the weevils readily work out from these depths.

From a further careful field study it was noticed that not only did this shallow plowing under of the fallen squares fail to destroy them in most cases, but conditions were often such as to make this shallow covering of loose soil over them a positive advantage. In those sections where cotton does not grow rank, and permits the direct scorching rays of the sun to strike the soil between the rows, it was found that many fallen squares with weevil larvæ in them were so thoroughly heated that the larvæ perished. Earlier in the season the industrious little red ants are busily engaged in search for food and they often eat into the infested squares and destroy the larvæ or pupæ inside. Now if these squares be plowed under, the shallow covering of earth takes them out of reach of the friendly little ant, and also away from the scorching hot summer suns to a cool, moist place underneath. As soon as the larvæ mature in the plowed-under squares, the weevils which they produce find little trouble in coming to the surface and escaping. The process is therefore a positive injury under these conditions and must be condemned.

Conditions which afford shade, coolness, and sufficient moisture are ideal ones for the full development of the weevil. Hence, rank-growing varieties of cotton are not advisable, since on the rich bottom lands, where moisture is better conserved and cotton grows so rank as to completely shade the ground, the weevils are more plentiful and destructive than in the prairie and uplands.

RATE OF INCREASE OF THE BOLL WEEVIL.

Many planters are often indifferent to the boll-weevil campaign in spring because so few are found in their fields. To indicate how great a menace a few in spring are to the crop later on, the accompanying tables have been prepared.

It should be remembered that the adult female lays from 50 to 150 eggs, and that a complete generation is developed at least once each month.

The estimate of the bolls and squares per plant per acre is based upon cotton planted $1\frac{1}{2}$ feet apart in the row and the rows $3\frac{1}{2}$ feet apart. Upon that basis there would be, to use round numbers, 8,300 plants per acre. The squares indicated for each succeeding month are estimated as being in addition to those already produced.

In making up these tables, only a pair of weevils is taken into account, for the reason that very early in the season the weevils are so few and so scattered as to make it difficult to find them on the very small cotton. In fact, at the beginning of the season, not more than two or three weevils can be estimated for every 2 or 5 acres.

The amount of injury is estimated upon actual observations of the

feeding capacity of the adults, namely, that each adult weevil will attack at least one square each day and injure it sufficiently to cause it to fall. In the amount of injury is included that resulting from the feeding of the males for only one month, for the reason that they are short lived and doubtless die within that time. Account is taken of the feeding of the females for two months, since all evidence indicates that their egg laying is finished by that time and that they die soon after.

The rate of increase is estimated upon an egg-laying capacity of fifty eggs per female, which is the minimum rate so far as yet ascertained.

It should be stated by way of precaution that these tables are not to be taken as absolutely correct. They are only approximate and submitted to enforce the argument in favor of securing early fruitage in the cotton planted, and to show that this advice is based upon principle and not on opinions.

Table 1 shows what numbers will be attained if a pair of weevils is left to breed unchecked by any methods of warfare.

TABLE 1.—*Increase of Mexican boll weevil if left to breed unchecked.*

Month	Number weevils per acre.	Squares eaten per month per acre.	Squares produced per month per acre.	Uninjured squares left per month.	Squares produced per plant per month.
May 1.....	2	60 1,500 <i>a</i> 30	8,300	8,240	1
June 1.....	50	1,530 37,500 <i>a</i> 750	41,500	39,970	5
July 1.....	1,250	38,250 937,500 <i>a</i> 18,750	83,000	44,750	10
August 1.....	31,250	956,250	249,000	-----	30
Total <i>b</i>	-----	-----	-----	92,960	46

a Number of squares injured during the month by females left over from previous months. This is half the entire number for that month feeding at the rate of one square per day. This note also applies to Table 2.

b The total of uninjured squares is for July 1, while that of squares produced per plant is for August 1.

Table 2 is the rate of increase based upon the supposition that one-half are destroyed by applying the methods recommended for protecting the crop. This is a minimum result which might be expected from any kind of successful warfare, and is submitted simply to further illustrate the advantage gained from determined effort, also the importance of the use of early-maturing or early-fruited varieties of cotton.

TABLE 2.—*Increase of Mexican boll weevil when one-half are destroyed by application of methods recommended for destruction.*

Month.	Number weevils per acre.	Squares eaten per month per acre.	Squares produced per month per acre.	Uninjured squares left per month.	Squares produced per plant per month.
May 1	2	60 750 a 30	8,300	8,240	1
June 1	25	780 9,000 a 360	41,500	40,720	5
July 1	300	9,360 112,500 a 4,500	83,000	73,640	10
August 1	3,750	117,000 1,406,250 a 56,250	249,000	132,000	30
September 1	46,875	1,462,500	415,000		50
Total b.....				254,600	96

a Number of squares injured during the month by females left over from previous months. This is half the entire number for that month feeding at the rate of one square per day.

b The total of uninjured squares is for August 1, and that of squares produced per plant is for September 1.

NORTHERN-GROWN COTTON SEED AND EARLY-MATURING VARIETIES.

Attention has already been called to the advantage of securing squares on the plants as early as possible in order to confine the egg laying and the gathering of infested squares to the trap rows. This is easily accomplished either by planting cotton seed grown in a latitude as far north as practicable, or by planting extra early fruiting and maturing varieties.

There is another important reason why the same principle should be adopted in selecting the seed to be used for the main crop, planting of which follows the trap rows. From Table 1 it can be noted under rate of increase that it requires the early portion of the season up to mid-summer for the weevils to breed and become numerous enough, even if given full sway, to produce one weevil for each square that the plant can produce. It is well known in the Brazos and Colorado river bottoms that home-grown seed produces plants whose tendency is to make a large and vigorous growth early in the season and to set its crop of bolls later. Hence, it does not begin setting much fruit until July, which, according to Table 1, is the time when the weevils have become numerous enough to prey upon each square as it is produced. Extra early varieties, or the same varieties with seed obtained from farther north, begin fruiting freely three weeks to a month sooner, and set a fair crop of bolls beyond the reach of boll weevils previous to the month of July. Seed from Indian Territory planted in the Colorado River bottom in Colorado County, Tex., has been observed to set fully enough bolls for one-half bale per acre by the middle of

July, before boll weevils had become numerous enough to cut them off. After this time the growing plant continues producing new squares until frost, and the weevils finding ample food in them, allow the bolls set before that time to escape attack. This is upon the basis of giving the boll weevil full sway.

If any serious effort is made to gather and burn the infested squares the danger season will be postponed until the end of August, which will insure practically an average crop. Table 2 is estimated upon the basis that only one-half of the breeding of the pest for the season is destroyed. Even upon this basis a study of the table makes it evident that the month of August is clearly placed on the safe side of the danger line.

But no such poor results follow methods heretofore recommended (trap rows and gathering), and practical immunity can be insured if proper effort is made.

FUMIGATING INFESTED COTTON SEED.

The fact that cotton seed produced in the weevil district has a tendency to make a large plant growth before beginning to set bolls is not the only objection to be urged against its use. In discussing the life history and habits of the weevil, it was noted that many were gathered along with the seed cotton carried to the gins, the cotton ginned, and the weevils escaped destruction by coming out with the seed. The first beginnings of weevil infestations are often directly traceable to the cotton seed bought for planting purposes from badly infested sections. The seed should, therefore, be treated as it is ginned and stored. For this purpose use a pound of carbon bisulphide for every 25 to 50 bushels of seed. Sprinkle it freely over the seed as the bins are being filled, and repeat the operation frequently. The fumes are heavier than air and will permeate downward. When the bin is filled, close all the openings securely.

VOLUNTEER COTTON.

The cultural methods advised thus far apply more especially to those districts where the seasons of the year include severe, or at least killing, frosts. In those sections where cotton stalks do not die, or are only killed down to the ground, the methods suggested are not so applicable. The method of grazing hereinafter discussed is especially applicable to such sections, and early spraying, also to be discussed later, becomes an important factor.

At this time, therefore, there seems to be no reason why volunteer cotton culture should be condemned where that system is practicable.

It should be remembered, however, that any method to be successful must be accompanied with the gathering and burning of the squares. The pan-shaking method at this time seems feasible and practicable only for the trap-row system properly developed.

GRAZING OFF THE COTTON.

During midsummer there is little which can be done practically or economically, and if methods of warfare are not applied early in the season the unfortunate planter must be satisfied with the fruits of his negligence, and resolve to begin the fight promptly with the next crop. As the fall season approaches there is an extremely important move to be made. It is well known that cotton keeps on growing and producing squares until severe frosts cut it down. It is also well established that squares which do not bloom within six weeks of frosts have but little chance of maturing fruit. The immense crop of squares produced during this period serves no other purpose than that of food and places for egg laying for the great numbers of weevils which have developed. These facts put us face to face with the problem: How to dispose of these squares and destroy the weevils, and at the same time lose as small a quantity of maturing bolls as possible. This problem has been most happily solved by inaugurating the practice of turning in herds of cattle and grazing the cotton. The stock will eat the tender growing tips, where are found the young squares. These are the portions of the cotton first eaten. With them go eggs, larvæ, and adult weevils. There is practically no escape. The all-important point to note is that this grazing must be done before the first frost. The first danger of freezing starts the weevils out on their search for hibernating quarters, and they gradually leave the cotton. The fact that the weevils are yet in the cotton when grazing begins makes it impossible for many to escape. The boll weevil fight can be won by practicing this grazing process thoroughly. One difficulty which sometimes arises is that occasionally a planter allows a heavy crop of crab grass to grow in his cotton fields late in the season. This is excellent forage, and when stock is turned in to graze the animals feed on the crab grass first, and but lightly upon the cotton until the former has been consumed. Clean culture is therefore essential to the greatest success of this method. If clean culture can not be maintained this grass should be set fire to and burned before the stock is turned in. This rubbish affords winter protection to the insect enemies of the cotton, and in any case should be burned on general principles.

Another difficulty in securing a general acceptance of this method lies in the fact that there is a small percentage of immature bolls which might yet open, but which the stock eats. Again, the scarcity of pickers sometimes results in the planters being far behind with their picking. This is the planters' misfortune and not the fault of the method suggested. Much depends on their management along this line. As for the small quantity of immature bolls which the stock eats, their loss, when contrasted with the benefits derived in the way of practical immunity from weevil attack for another crop, must seem too insignificant to seriously militate against the general application of

the method. This practice comes as near being absolutely eradivative in its results as any that has been tried. Just in proportion as it is applied will the cost of the weevil campaign in spring be diminished. Its application costs nothing, for, as a matter of fact, it is applied at a time when pastures are short, and so far as the stock is concerned, the practice is of positive advantage. There is one precaution to be observed, and that is to make sure that a good drenching rain has followed the last application of any poisons to the cotton. If such has been the case, there is positively no danger to the stock from grazing it.

TRAPPING THE WEEVILS INTO HIBERNATING QUARTERS.

After the cotton stalks have been divested of foliage and squares by grazing, they should be pulled, cut down, or plowed out, and piled in windrows across the field and allowed to remain to dry thoroughly. If any weevils have escaped the grazing process, they will collect in this rubbish for hibernation instead of going out to the timber and rubbish along fences, highways, and byways. In this manner the escaping weevils are actually trapped into hibernating quarters just where you want them. When this has been accomplished set fire to the windrows and burn up stalks, rubbish, weevils, and all. This method, coupled with that of grazing, as outlined, can have no other result than practical eradication.

It should be stated that allowing the stalks to remain standing during the winter and then gathering and burning does not have the desired effect, because the weevil does not and can not utilize them for protection while thus standing, and hence goes elsewhere for shelter. For this reason, also, windrowing the stalks after frosts does not have the desired effect, since it does not act as a trap during the period when they are seeking winter quarters. Previous to windrowing the cotton stalks, corn and stubble fields should be burned; also anything else which could afford the weevils protection. Just how to proceed with the labor of windrowing the stalks must be a matter for each planter to determine.

As soon as possible after all rubbish has been burned, the fields should be plowed as deeply as practicable, for two reasons: (1) To plow under and destroy all the squares and rubbish yet on the ground makes it impossible for any larvæ to mature and produce weevils; (2) it breaks up the cells in which the bollworm transforms during winter, thus destroying them also.

IS THE BOLL WEEVIL MIGRATORY?

The above question is suggested by the fact that the cotton-growing territory of the State invaded by this pest from its first spread across the Mexican border is now practically free from it. This freedom is coupled with the idea in the minds of the planters that the weevil

infests any given locality only for a time, and then disappears or migrates. Though not solved in all its details, much light can be thrown on this problem.

As has been previously indicated, the weevil thrives best and breeds most freely under conditions of liberal, though not excessive, humidity, accompanied by plenty of shade for the ground. The latter is afforded by the rank-growing cotton of the rich bottom-land sections. Such conditions are normally and essentially lacking for the greater portion of the supposedly immune territory in question. The weevil had been introduced and had attracted much attention in some portions as early as 1893. With normal rainfall from that time until 1895 and a portion of 1896, the pest multiplied rapidly and made such havoc on the cotton crop of southwestern Texas as to practically destroy it.

With 1896 began a period of drought and much distress among the farmers and cattlemen. Rainfall for this territory being rather limited at best, was even less abundant for the year 1897, when an unprecedented drought afflicted Texas generally and that section particularly. The year following was still considerably below normal in rainfall, thus making a series of three years of drought. The soils for the most part are sandy loams, and under the climatic conditions mentioned the plant growth of cotton was very greatly reduced. The conditions of drought made the rays from the scorching hot sun all the more penetrating and heated the light sandy surface of the soil to an unusual degree. One could hardly walk over it with bare feet. Hence two important conditions—shade and moisture—favorable to the weevil, were lacking. In addition, many thousands of the fallen squares became so heated while lying on the ground that the larva in them perished.

The conditions which make a scant plant growth for cotton also cut short the range for grazing. They have the further effect of maturing the bolls set very much earlier than usual. This resulted in the crop being gathered correspondingly earlier, with a few immature bolls remaining. Under these conditions the farmers and cattlemen, in the extremity of their distress, gathered in their cattle and grazed off the foliage and every tender portion of the cotton. As has already been outlined, no practice could have been more eradivative in its tendency; and, though not intentionally, the planters and cattlemen contributed most materially to the practical extermination of the pest within their borders. The three successive years of drought led to the quite general establishment of this grazing practice, and if the farmers and stock raisers of that section will only maintain it they have little to fear from the boll weevil.

It would therefore seem that the weevil was practically eradicated through force of circumstances rather than that the pest migrated *en masse*. It also suggests that, should there come a period of unusual rainfall for a few years in the territory now free from the pest and

the beneficial practices outlined be neglected, it would only be a question of sufficient time during which to breed when the crop in that section would again be ravished as seriously as ever.

What has been stated practically answers the second question negatively. In the sections of abundant rainfall, rich soil, and luxuriant growth, furnishing ideal conditions for breeding, there is no ground for hope that the boll weevil is likely to leave us.

DIFFICULTIES OF PRACTICING CULTURAL METHODS.

The real secret of the temporary unpopularity of the cultural methods lies in the baneful peculiar labor and tenant system in vogue among land-owners and planters. Often a planter goes to his plantation and outlines the steps to be taken to control the boll weevil. Immediately a cry comes up from the tenants who rent the lands that this is extra work and that they should be paid wages for gathering up the squares from the acreage which they are renting. The trap rows require a little extra labor and headwork, and both are burdensome to the average tenant. Unfortunately, in 95 per cent of the cases the planter has already "furnished" his tenant, so that he is compelled to keep him and have him grow some kind of a crop to reimburse him, at least partially.

In the fall, when it comes to utilizing stock to graze off the cotton and the weevils with it, the tenant again raises the objection that he has made what little crop there is and is unwilling to lose the chance of a few more bolls ripening. The tenant oftentimes has already decided to try another plantation the next year, and he is determined to give every boll a chance to mature. This changing about delays operations at the very time when active warfare should be waged.

This further explains why the small landowner who does his own farming, and as a rule has his own labor, has not raised a voice against the methods herein recommended. On the contrary, he is quietly practicing them with marked success in all parts of the weevil-infested district. Contrast this with the tenant who is in debt to the planter, is furnished from the plantation store, and who is bent on getting as much return for as little labor as possible.

For these reasons it is easy to understand why more numerous complaints have come from the large plantations only, and why their losses and damages have been so great. With no absolute control over their labor and farm management except for the season of one crop, instead of continuously from one crop to the next, there can be no other result. These unfortunate conditions are not subjects of investigation for the entomologist. It is his sphere to discover ways and means of relief which are practical, economical, and effective entomologically speaking. The problems of labor, tenants, and the industrial conditions must be met and mastered by the planters themselves.

TRAP CROP FOR THE BOLLWORM.

Some planters have objected to the trap-row system, which delays the planting of the main crop, for the reason that if delayed the crop will lose what has been gained over the boll weevil by a greater attack from bollworm later in the season; in other words, they insist upon getting in the whole crop as early as possible. In this connection attention is called to Bulletins Nos. 24 and 29 of the Division of Entomology, United States Department of Agriculture, which discuss the trap crops to control bollworm ravages. Briefly stated, they are about as follows:

Corn, both in bud and roasting ear, is the first-choice food plant of the bollworm. Cowpeas rank second. It is generally conceded that no extensive or serious damage is done the cotton by the bollworm until about the time the corn crop matures. This is due to the fact that corn has gotten too hard, the stalk has ripened, and the female moths are compelled to go to cotton. For this reason a few trap rows of corn are planted, using the genuine midseason Mexican June corn. This must be planted late enough in the season so that it begins making roasting ears about the time the main crop has fully hardened. The female moth is attracted to the trap corn and deposits her eggs on the silk and roasting ears, and the cotton escapes. To make doubly sure, cowpeas are planted between the corn rows at a time to make them begin blooming shortly after the main crop of corn has ripened. These pea blooms form a great attraction for the female bollworm moths. This compels the breeding and feeding of the midsummer brood of bollworms on these two trap crops. The brood next following this is thereby thrown too late in the season to do any serious damage to cotton. In fact, when the bollworms are thus crowded from hundreds of acres of corn into a few trap rows, they become cannibals and feed upon one another in the overstocked roasting ears of the trap rows. For that reason, also, there need be no fear of a serious attack later.

It has already been urged that early maturing varieties of cotton be planted, or seed from as far north as possible, so as to induce earlier fruitage. This gain in time of fruiting more than offsets the delay caused by withholding planting, on account of the trap-row system. The midsummer brood of bollworms being trapped, the cotton will suffer no greater attack from them than it would ordinarily have been subjected to had the home-grown seed or late-fruited varieties been planted as early as possible.

EXTERMINATION BY SPRAYING.

There has been a great demand for remedies—poisons and boll-weevil machines. The distressed planter, accustomed to the use of poisons and some kind of machine in his warfare upon cotton insects, at first seemed bent upon being satisfied with nothing less.

SOME ERRORS IN SPRAYING.

It should be remembered that the weevils do not eat exposed surfaces of the plant, their almost invariable place of feeding being in the squares, safely sheltered by the involucre or shuck. Even here they

do not feed upon exposed surfaces, but eat a small hole to the inside and feed on the inner portions. In the spring, before squares are formed, they feed, when driven by necessity, upon almost any portion of the plant, but almost invariably the outer bark is first rasped and peeled off before feeding underneath. On account of this peculiar habit, it is at once evident that poisons and powders, either sprayed or dusted upon the plants, can be of little or no service, because the surface on which they are found is taken off and thrown aside. Another grave error relates to the manner of spraying. Practically all designs for spraying apparatus which are at all adapted for use on field crops are modeled upon the principle of horizontal supports for the spraying nozzles. Many of these machines have been tested and found useless, and for the following reasons: The cotton plant has a tendency while young to make a large plant and profuse leaf growth. The leaves overlap in such a way as to offer a more or less unbroken surface, protecting everything underneath. Hence spraying from horizontal supports downward over the plants would reach and cover only the upper surface of the leaves. The solution applied also has a tendency to run off like water from a duck's back. When the weevil travels in search of squares it crawls on the stems and limbs, rarely if ever getting upon the top of a leaf. These stems and squares being largely protected by the foliage overhead, the cotton may be thoroughly drenched in the ordinary way and yet the weevil may safely go about its business without ever coming in contact with the sprayed surface. The folly of this kind of spraying must therefore be apparent.

Spraying against boll weevils has been brought somewhat into disrepute by recommending remedies which, in themselves, may be efficient, but failing at the same time to devise and advise the proper apparatus with which to apply them.

SUCCESSFUL SPRAYING.

The errors just pointed out indicate the conditions under which spraying will be successful. As the weevil eats its food in a manner that it can not be made to eat poison along with it, the problem then is: Can it be induced to eat poison when presented in the form of a food itself? The fondness of most insects for sweets is well known, and the weevil is no exception. It has been ascertained that the pest is fond of cane or sorghum molasses when applied to the cotton. Hence, if any suitable poison in soluble form be included with this molasses the weevil will be poisoned and fall a victim to its appetite for sweets. Experiment has definitely proven in practice that the weevil accepts the poisoned molasses and is destroyed.

To reach the stems and the squares over which the weevil travels, the spraying must be done at right angles to the vertical axis of the

plant, with nozzles distributed vertically instead of horizontally. Actual field tests have proven that with this kind of an adjustment the main stalk, all the side branches, the small stems, and the squares can be thoroughly covered with the poisoned molasses solution. This spreads an inviting feast before the weevil wherever it travels about on the plant. Its fondness for sweets induces it to eat and its death is the result.

SPRAYING MACHINES.

The kind of apparatus to use will depend largely upon the acreage to be treated and the season of year when the spraying is to be done.

(1) **Knapsack sprayers for trap rows and small acreages.**—For the farmer having 10 to 20 acres of cotton there is no more practical apparatus than the knapsack sprayer. It holds about 3 gallons, and is provided with leather straps which fit over the shoulder. When filled, the workman takes the machine on his back. The pumping is done with one hand while the nozzle is held to the plant with the other. The operator should have an extension cane with an elbow for the nozzle. This will enable him to direct the spray most successfully to all the inner portions of the plants.

Spraying with a knapsack machine is especially advisable in treating the trap rows. With the nozzle at the end of the extension cane, the spray can be forcibly directed into the whorl or leaf buds in the top of small plants. With this apparatus the spraying is done more perfectly on very young cotton than is possible with the larger machines. When the plants become larger the knapsack becomes impracticable. Ordinarily a good active workman can spray 10 or 15 acres a day when cotton is small, and proportionately less as it grows larger. For those having their own labor and only a small acreage in cotton these sprayers are the most economical.

(2) **Aspinwall sprayers for large plantations.**—When hundreds or thousands of acres are to be sprayed, the knapsack, spraying 10 to 15 acres per day per machine, is too slow a process. If enough machines were bought and a sufficient number of laborers employed to do the work, it would be done quickly and efficiently. This, however, would involve a considerable demand for labor at a time when laborers are scarce or are badly needed for other work. To meet the conditions when large acreages are involved, a properly arranged boll-weevil attachment should be adjusted to the automatic sprayers. These machines are drawn by horsepower and do the pumping and spraying automatically as the team pulls the machine along. The vertical nozzle arms are adjusted and the nozzle attached so as to spray into the cotton plant as already explained. Results of tests with these machines have exceeded expectations, for no part of the plant escaped being well covered with the poisoned solution. One hundred acres can be sprayed per day per machine when cotton is small. When it gets larger more

nozzles have to be used. This requires more material and more frequent filling, hence a proportionally less acreage is treated per day.

For the large rank cotton of the river bottoms the nozzles must be adjusted to spray from the ground to the top of the plant. When cotton gets to be 5 or 6 feet high a long slender pole or iron pipe should be run in behind the whiffletree chains in front of the machine and crosswise of the rows. This catches the tops of the cotton and bends the plants over so that they are sprayed perfectly from underneath and for their entire length on stems and branches, as well as on the young growing tips, where the weevils are most plentiful.

LAYING OFF THE ROWS.

In order that the greatest success may be achieved with spraying operations, it is of prime importance that the rows should be laid off regularly and equal distances apart. This will be evident when it is remembered that a number of rows are sprayed at one time. If the nozzles are adjusted to spray rows thoroughly at a certain distance, it is evident that rows nearer together or farther apart can not be so well sprayed unless another adjustment of the nozzles is made. It is immaterial how great or small the distance between the rows may be, provided that distance be maintained uniformly throughout.

INGREDIENTS OF SPRAY.

The ingredients of the spraying solution should be mixed in proportions suited to the season and the conditions. In spring, before squares are formed, the weather is cooler and there is little danger of injury to the plant. Then, too, the exposed surface is smaller and a sweeter solution has been found to be desirable. Especially is this true for the trap rows. The proportions best suited for the trap rows and the first one or two sprayings of the main crop until squares begin forming, also for the later sprayings of the main crop, are given below:

Trap-row formula.

2 gallons cane or sorghum molasses.
2 ounces arsenic (90 per cent) boiled in a gallon of water until dissolved.
4 ounces arsenate of lead or disparene dissolved in a gallon of water
46 gallons of water. Mix thoroughly.

Main-crop or midsummer formula.

To be used on main crop as soon as squares are forming freely.
1 gallon cane or sorghum molasses.
1 ounce arsenic (90 per cent) boiled in a gallon of water until dissolved.
6 ounces arsenate of lead or disparene dissolved in a gallon of water.
47 gallons of water. Mix well.

The free arsenic is a dangerous poison to use on cotton when the plant begins setting squares, for the reason that its penetrating, scorch-

ing effect easily causes cotton to shed. This is especially true if the solution used is a trifle too strong in dissolved arsenic and its application is accompanied by the scorching hot suns of midseason. Hence, after squares are being produced, a lesser proportion of arsenic is used and the insoluble arsenate of lead is increased. The proportion of molasses is reduced, for the reason that, when the plants get larger, so much greater quantities of the solution have to be used per acre that the cost of the molasses becomes quite an item of expense. Then, too, the plant surface is larger, the weevil comes in contact with the sweetened bait more freely, and a lesser amount will answer the purpose. If, however, the planter makes his own molasses and has plenty, it will be advisable to use 2 gallons of molasses in each formula. Avoid using glucose or sirup, as they are inclined to gum and clog the nozzles.

The arsenate of lead, when thoroughly mixed with the molasses, causes the solution to adhere better, and tends to prevent its running off so readily in case of rains or heavy dews.

It is a poison and is itself rather sweet, so that, in addition to its adhesiveness, it increases the probability of poisoning the weevil. Heavy dews dissipate the dissolved arsenic too freely, and as the arsenate of lead is not soluble in water, it is more lasting, and has less tendency to cause shedding by its too free or frequent use in repeated sprayings. For this reason the quantity is increased in the midsummer formula.

WHEN TO SPRAY.

The fact that early in spring the weevil is compelled to feed more exposedly on young cotton makes it of the greatest importance to spray while that condition continues, or until squares begin to be produced. The cotton should therefore be sprayed once and thoroughly before the first squares are formed. Of course, the first spraying should be upon the trap rows. On these the sweeter solution should be used. For the first application to the main crop, the trap-row formula should be used, but as soon as squares begin to form freely on the main crop the second solution is recommended. In ordinary seasons, when the planter can work and plan with some certainty, there should be no occasion to continue spraying throughout the entire season.

It is to be noted that the cotton plant grows vigorously during the early portion of the year and midsummer. The increase in exposed limbs and surfaces, due to the new growth at the growing ends of the branches and main stems, confronts us with the proposition that a week after spraying the plant has doubled in exposed surfaces and foliage, and hence but half the plant is covered with the poisoned solution. The portion not covered is the young and tender part, which constitutes the choice lodgment for the weevil. Hence up to midsummer, while cotton is thus growing so rapidly, the entire fields should be

sprayed once a week, or until it is apparent that the weevil has been checked and is fully under control; in that case, or as soon as the cotton checks up in its new growth, the intervals can be extended to one spraying every two weeks.

CONCLUSIONS.

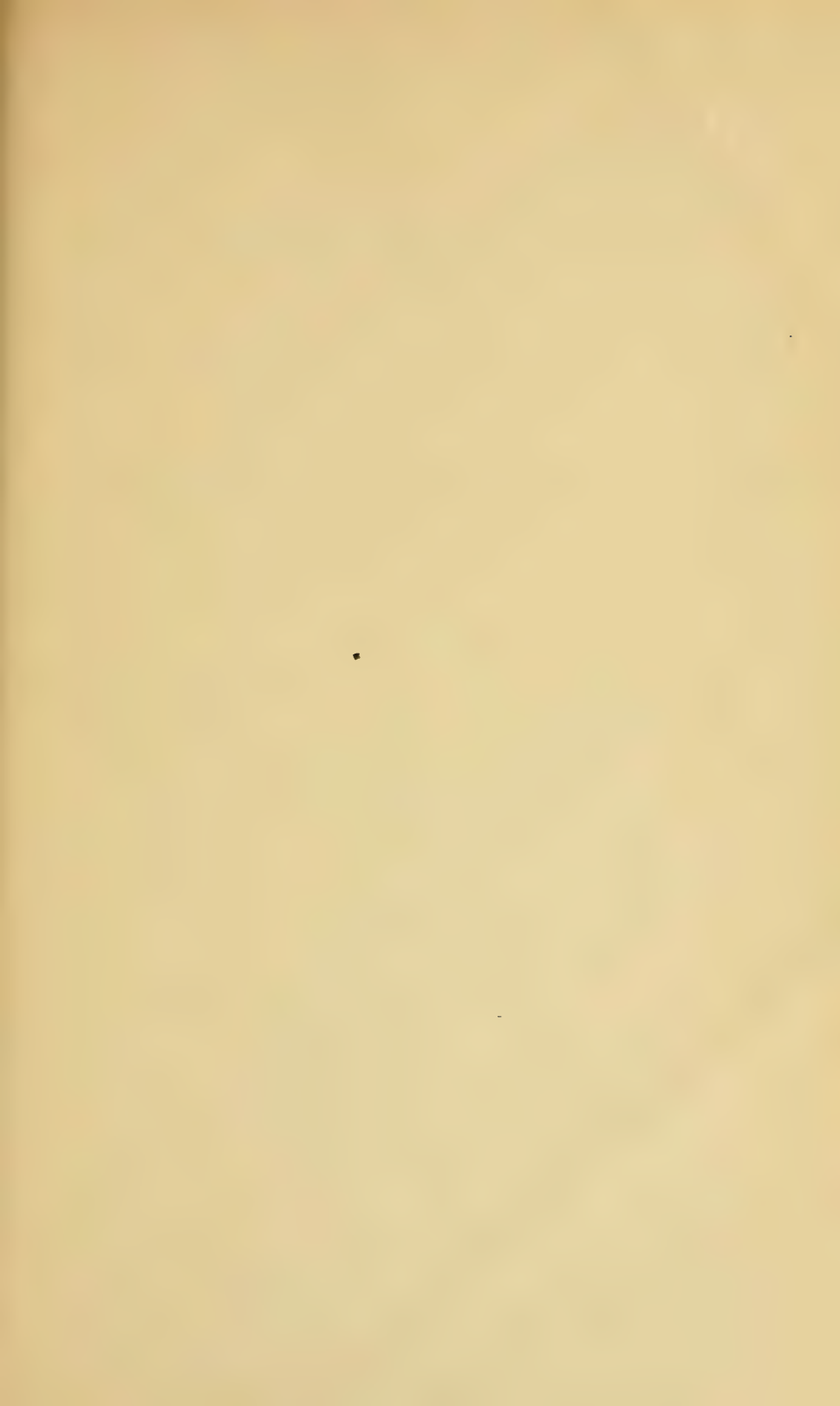
Without doubt spraying is effective and advisable if suitable poison solution can be prepared and then applied with suitable apparatus. However, it must be plain from the discussions in the foregoing pages that spraying should not be depended upon solely, but in conjunction with the cultural methods. Neither system used alone will attain the greatest efficiency. If either one is to be depended upon alone, the cultural methods are far more economical and efficient, and are capable of more general application under a greater variety of conditions. There can be no question of the desirability and the advantage of spraying, but it should be secondary, and should be practiced in conjunction with the cultural system.

Another reason for spraying is that the application of poisons makes sure of destroying all insect pests of cotton which feed upon its foliage. The careless worm (also called web worm) on cotton early in spring is completely destroyed. Then, too, the early scattering broods of the leaf worm, or army worm, are poisoned and all the tremendous expenditures for poisons and poisoning late in the season against these pests are largely saved.

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The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

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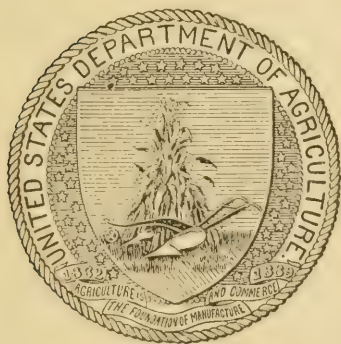
FARMERS' BULLETIN No. 132.

THE PRINCIPAL INSECT ENEMIES OF GROWING WHEAT.

BY

C. L. MARLATT, M. S.,

First Assistant Entomologist.



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(originally issued in 1901)

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., April 6, 1901.

SIR: I have the honor to transmit herewith for publication an account of the more important insect enemies of growing wheat, prepared by Mr. C. L. Marlatt, first assistant entomologist. This paper is the address, slightly revised, delivered before the Winter Wheat Millers' League, in Chicago, June 13, 1900, and was prepared under my direction in response to an earnest request from the secretary of the league, Mr. E. E. Perry. As showing the importance of the subject it may be stated that the publication of this paper and its general distribution among the winter wheat growers of the Mississippi Valley was desired by the league, with the view of limiting the losses from insect pests, and notably the Hessian fly, the ravages of which last-named insect in 1899-1900 so reduced the normal yield of wheat as to seriously interfere with the winter wheat milling interests. The paper is a condensed account of the principal insect depredators on growing wheat, discussed chiefly from the standpoint of means of control, and as covering an important subject and being a valuable aid to the correspondence of this division its publication as a Farmers' Bulletin is recommended.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE PRINCIPAL INSECT ENEMIES OF GROWING WHEAT.

INTRODUCTION.

There are numerous insects, the number running into the hundreds, which feed on and injure growing wheat. Most of these insects are of rare or chance occurrence, and have no economic importance whatever, although the fact that they are found on wheat often leads the farmer to be curious about them or unnecessarily arouses his fears. The great proportion of the losses to wheat fields which is chargeable to insects is due to the attacks of less than half a dozen species. These, in the order of their importance, are the chinch bug, the Hessian fly, the wheat midge, and the grain plant louse. Of second-rate importance are such insects as the wheat strawworms, the wheat bulb worm, army worms, cutworms, and various sawflies. Then there follows a great horde of insects of minor importance which need not be considered in this connection. This is leaving out of consideration the locusts, or grasshoppers, including the Rocky Mountain, or migratory species, which occasionally injure wheat, but such injury is unusual and as a rule limited to migrations of locusts from one section to another, which are of infrequent occurrence nowadays, at least in the principal winter wheat growing regions, and have never been noteworthy except in the western districts.

The reason for the excessive damage by the various grain pests noted in this country is not hard to discover. Our system of growing the same grain crops over vast areas year after year furnishes at once the very best conditions for the multiplication of the insect enemies of such crops. In addition to this is the fact that America, with its long, hot summers, presents the most favorable conditions for the multiplication of most insects. These two reasons undoubtedly account for the far greater losses experienced in this country as compared with Europe, the summers of which are very cool and short. Furthermore, in Europe farming is on a much more intensive scale. The holdings are small and carefully inspected, and any insect outbreak is promptly taken hold of, and in addition to this a regular system of rotation of crops is often practiced.

The losses occasioned by the insects mentioned above exhibit a wide range in different years, due as a rule to favorable or unfavorable cli-

matic conditions, and also to the abundance from time to time of the parasitic and other enemies, which is a natural sequence of the multiplication of the host insects. This results in a more or less striking periodicity in the recurrence of the common grain pests. Fortunately in many instances these periods of unusual abundance are separated by wide intervals of comparative freedom. Sometimes, also, a season which is unfavorable for one insect is favorable for another. Hence we have not only a periodicity in the recurrence of the same insect, but a more or less marked rotation of the different species. All of this emphasizes the need on the part of the wheat grower of a thorough acquaintance with these different insect enemies, and with the climatic and other conditions which are liable to promote their abundance, and especially with the measures which may be taken to prevent or limit loss.

The annual losses resulting from the attacks of these several insects on wheat is undoubtedly very great, running far into the millions in bad years, no very considerable percentage of which is made good by the enhanced value of the remainder of the crop. Much of this loss can undoubtedly be prevented by proper attention to cultural methods and the adoption of known remedies.

In the accounts of the chief wheat pests which follow, an effort has been made to give a brief presentation of the life histories of the several species treated, with special reference to the bearing of remedial and preventive measures.

THE CHINCH BUG.

(*Blissus leucopterus* Say.)

The chinch bug (fig. 1) is certainly responsible for as great annual losses to farm crops as any other injurious species of insect known, and it is very improbable that any other species causes anything like the damage which is chargeable to this pest. This is due to its wide distribution, its prevalence more or less every year, the enormous multiplication in favorable seasons, and to the fact that it attacks all the cereals and most forage plants. The losses caused by it vary greatly in different years, but are always experienced more or less in some locality or other. These losses may often amount to a very large percentage of the wheat and other cereal crops, and also later of the corn crop, and throughout the season of various forage crops. The losses for single States in one season have been estimated at from ten millions to twenty millions of dollars, and for single years throughout its range at above a hundred million dollars. Large as these figures are, when the actual estimates of shrinkage of yield of wheat and other grains, not to mention forage crops, are made, it will be seen that they are reasonable and probably within the true amount. Much

of this loss undoubtedly can be avoided by a proper system of farm management and the adoption of known methods of control.

The important natural agencies responsible for the abundance or scarcity of this insect are not insect parasites, for it has none of any importance, but unfavorable climatic conditions and the various diseases induced thereby. The chinch bug is notably an accompaniment of drought, and very rarely, if ever, is serious injury caused by it in other than dry seasons. Wet weather is very prejudicial to it and develops various fungous diseases, which as a rule very promptly result in its practical extermination for the season. Unfortunately these weather conditions are not subject to control, and the chinch bug, therefore, is bound to be in evidence in dry years. It then becomes a matter of attention to whatever practical farm methods are available to prevent greater loss than necessary.

Distribution.—The chinch bug is a native insect, originally subsisting on various wild grasses in the Mississippi Valley and throughout its range. On this continent it is widely distributed (fig. 2), occurring from Nova Scotia and Manitoba southward to the Gulf. It occurs also in California, Lower California, and in Mexico and Central America, and also on several of the West Indian Islands. Over much of this area it is not often very injurious, and the chief losses occasioned by it are in the Ohio and Upper Mississippi Valley and lake region, and, to a less extent, northeastward throughout the Allegheny region, New England, and Nova Scotia. The Gulf States do not so often suffer serious injury from this insect, except occasionally, perhaps, in the rice-growing regions.

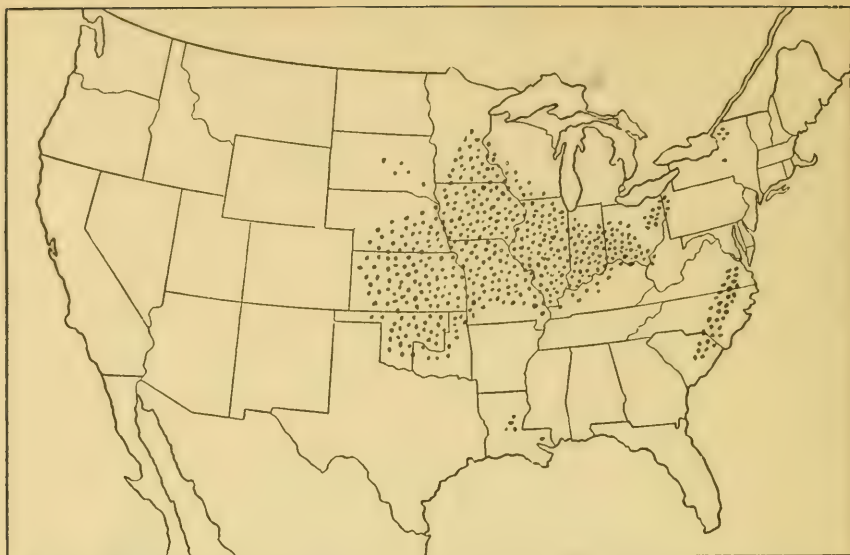
The losses resulting from the chinch bug are largely to the wheat crop, and it is one of the most important wheat pests. The losses to corn are almost always a result of migrations from wheat fields after harvest. The losses to grasses are less noticeable, although in some cases quite important.

Attention was first drawn to its ravages in the latter part of the last century, and the records of notable outbreaks and serious loss have been pretty constant since 1800.^a

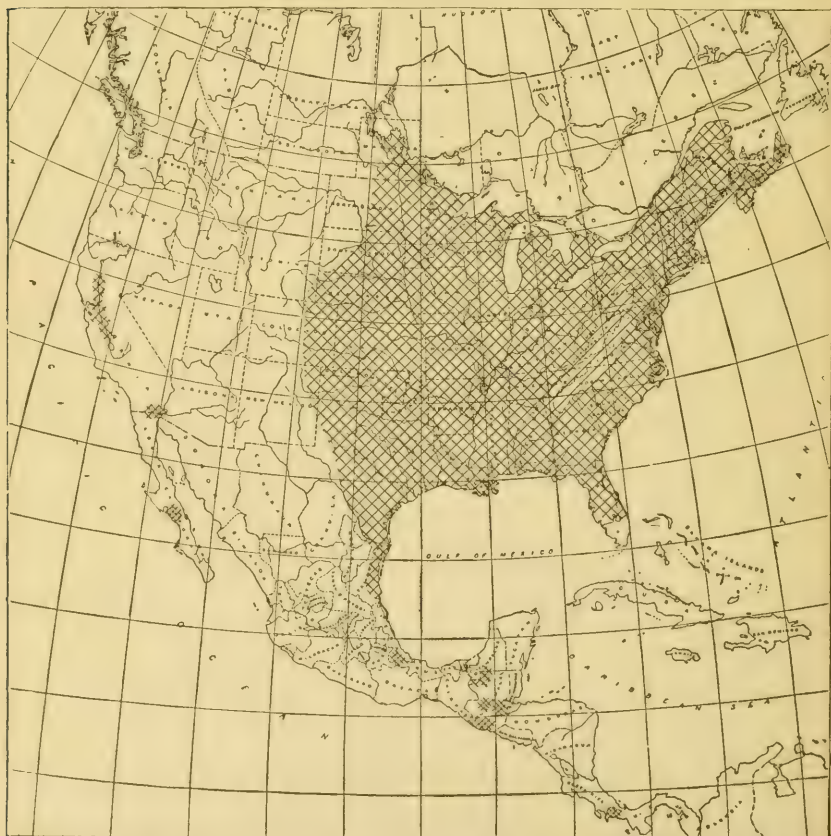


FIG. 1.—Chinch bug (*Blissus leucopneustus*): adult of long-winged form, much enlarged (from Webster).

^a A matter of no especial importance is the fact that along with the ordinary chinch bug, which is winged and capable of strong flight in the adult stage, there frequently occurs, especially in maritime districts, both of the Atlantic coast and the Great Lakes, a short-winged form (fig. 3), the wings of which vary from almost nothing to nearly full size. This short-winged form is associated with the normal type, and has the same habits except that it is not capable of flight. So far as the practical consideration of this species is concerned, the short-winged form may be ignored.



a, Areas in the United States over which the chinch bug occurs in most destructive numbers (from Webster).



b, Shows where chinch bug is found in the United States, but not in most destructive numbers.

FIG. 2.—Map showing distribution of chinch bug in the United States.

From the standpoint of control no feature of the life history of this insect is so important as its overwintering habit. The general belief has been that the species hibernates beneath rubbish, such as old straw, or matted grass, or leaves in hedge rows, and this is probably often the case to a certain extent, but undoubtedly the normal place of hibernation is in the dense stools, especially of wild grasses, and also of such cultivated grasses as incline to the stooling habit.

Autumnal flight.—Toward the last of September the chinch bug begins its autumnal flight, and very shortly thereafter disappears entirely from the fields of corn or other late crops. In this flight it frequently goes some distance from the fields which it has infested, and, finding in these grass stools favorable situations, works its way well down into the stool, almost or quite beneath the surface of the ground, or into the soil which has been caught and held by the dense bunches of grass. In these situations chinch bugs may be found during



Fig. 3.—Chinch bug (*Blissus leucopterus*) adults of short-winged form—much enlarged (adapted from Webster).

the winter, a single grass stool frequently harboring hundreds of insects. So marked is this hibernating habit that it is reasonable to infer that it is the normal and ancient one of the species, the natural food plants of which before the advent of settlement and the growth of cereals were these same native grasses. Where cultivation has destroyed these grasses, and the chinch bug is no longer able to find such localities for winter concealment, it undoubtedly hibernates under rubbish and in the other situations suggested. The bearing of this hibernating habit on remedies will be noted later.

Life cycle.—The annual life cycle of this insect may be exhibited by the following summary, based on a careful study, made by the writer in eastern Kansas. The dates given will hold for the middle region occupied by this insect, but northward there will be a retardation, and southward an acceleration, in the times of appearance and the development of the different broods.

April 10–20, spring flight from hibernating quarters in grass stools to wheat fields.

April 20–30, *in coitu* about the roots of wheat.

May 1–31, deposition of eggs on wheat roots beneath the surface of the soil, with young hatching from May 15 to June 15.

July 1-15, maturing of the first brood, followed immediately by the midsummer flight, if a migration of immature and adult forms has not been previously occasioned by the harvesting of grain or the local failure of the food supply.

July 15-30, union of the sexes and deposition of eggs in the soil about late corn or millet, the young of this brood appearing in maximum numbers about August 5.

August 20 to September 10, maturing of the second brood and partial flight of same to late corn or other green crops if in fields of corn already mature and dying.

September 15 to October 15, autumnal flight to grass lands and concealment in grass stools for hibernation.

Different stages.—The chinch bug goes through six different stages, from the egg to the adult insect. The egg is less than three-tenths of an inch long, cylindrical, and squarely docked at one end, in color pale or whitish when first deposited, but later showing the colors of the developing embryo through the shell. The newly hatched larva (fig. 4) is but little larger than the egg and resembles the adult insect in miniature except in having no wings. It is of a pale reddish color,

with a yellow band across the first two abdominal segments. The second larval stage resembles the first except in being larger, and having the head and thoracic segments dusky and hardened. After the second molt there is again an increase in size, and the head and thorax become still darker and more coriaceous. The next molt introduces the pupal stage of the insect, which resem-



FIG. 4.—The chinch bug (*Blissus leucopterus*): a, b, eggs; c, newly hatched larva; d, its tarsus; e, larva after first molt; f, same after second molt; g, pupa—the natural sizes indicated at sides; h, enlarged leg of perfect bug; j, tarsus of same still more enlarged; i, proboscis or beak, enlarged (from Riley).

bles the adult almost exactly, except that the wings are replaced by mere wing pads, which latter had already been foreshadowed in the last larval stage. The next molt results in the perfect insect. Nearly two months are required to complete this life cycle.

After hatching the chinch bug is extraordinarily active in all stages, even the minute larva being able to travel rapidly and to extract itself from a considerable depth of covering soil if necessary.

Habits.—In habits this insect is distinctly gregarious, associating itself in masses on the plants attacked, commonly going by preference to the lower portions of the plant and, in the early larval stage, even working on the superficial roots.

Migration.—The first brood is normally developed in wheat land, for the simple reason that when the chinch bug takes its spring flight wheat is the growing crop which is most likely to attract it. The wheat crop matures and is harvested, as a rule, before the first brood of bugs has reached maturity or at about the time they are entering the adult

stage. The ripening and harvesting of the grain deprives them of food and induces a migration, and the young, half-grown, and adult insects start off together, apparently with a common impulse, abandoning the wheat fields and attacking any near-by cornfield or grass field. Their travels, while commonly much less, may extend to a distance of a quarter of a mile or more, and, as a rule, under these circumstances the bugs are numerous enough to completely carpet the ground. Entering a field of corn, they congregate on the outer rows at first, fairly blackening the stalks with their bodies and absolutely killing the corn as they move inward. As a rule, the serious damage is on the edge of the cornfields, sometimes, however, extending inward several rods.

If this midsummer migration is not induced by the harvesting of grain, or where the chinch bugs develop in other situations, their reaching maturity is immediately followed by midsummer flight to corn or millet or other crop.

Crawl on ground.—Curiously enough, in the migration above noted the winged individuals, as well the wingless, all crawl together on the ground, and flight seems never to be attempted on the part of the adult. The second brood, maturing about the last of August and the first of September, may have a partial flight to late corn or other late crops if the cornfields in which they develop have already matured and are drying up, but between the middle of September and the first of October they take what may be termed the autumnal flight to grass lands or other situations for concealment and hibernation.

PREVENTIVES AND REMEDIES.

For the practical control of the chinch bug many suggestions have been made, some of which have a good deal of utility. These are considered in the order of their importance.

(1) **Burning over waste land.**—The hibernating habit of the chinch bug suggests at once the advisability of burning over and clearing up all waste land where this insect would be apt to congregate for overwintering. The burning of grass lands, especially the wild grasses which may have the stooling habit, should be done early in the fall so as to expose the chinch bugs that may not be killed by the flames as long as possible to the unfavorable action of the cold and freezing of winter. All the rubbish in the fence corners and hedge rows should be raked out and burned and as little material left as possible for protection of the insects. Cultivated meadows may be safely burned over when the ground is frozen without injury to the grass.

(2) **Trap crops.**—The planting of trap crops has been suggested and may occasionally be of some value. Of this nature is the early planting of patches of millet or Hungarian grass or spring wheat to attract the chinch bugs in the first spring flight. Such land after becoming

infested should be turned under with the plow and not planted until late in the season to other crops. The eggs thus buried will hatch in the soil, and, as a rule, the young insects will find plenty of avenues of escape; but if there be no near-by crops, they will ultimately perish, since they are unable to travel far at this stage. In the same way trap crops may be planted between wheat and corn to protect the latter from the migrating bugs from wheat fields after harvest.

(3) **Rotation.**—If a system of rotation could be adopted which would entirely disassociate small grains from corn, very little damage from the chinch bug would ever be experienced, at least to the latter crop. Following out this idea would mean the planting of a farm to corn one year and to wheat and small grains the next or some similar system of rotation.

(4) **Plowing as a check.**—In checking the midsummer migrating bugs some good may also be done by turning under the first rows of corn or other crop attacked. To have any practical value, however, the plowing must be done very deeply, or many of the bugs will escape.

(5) **Spraying.**—The first rows attacked by the bugs may also be sprayed with a very strong oily insecticide, such as kerosene emulsion—a mixture strong enough even to kill the corn itself and the bugs along with it.

(6) **Protecting furrows.**—The making of protecting furrows, as recommended for the army worm, is also applicable to the chinch bug. The bugs which collect in the furrow may be killed either by dragging a log along or by thoroughly wetting with the kerosene and water mixture.

(7) **Coal-tar barriers.**—A good deal of effort has been made in some places to protect fields by placing about them lines or barriers of coal tar. Where this is done the line of tar must be renewed several times a day. At intervals along it holes may be bored, in which the bugs will accumulate and may be destroyed. All that is necessary is to put a single straight line of tar in front of the migrating bugs and make holes on the side of attack with a post auger at distances of 8 or 10 feet close to the tarred line. Various other forms of barriers will easily suggest themselves, such as putting a line of boards about a field and smearing it with tar or combining the tar with the furrow method.

Promptness and vigilance are the essentials in any of these remedial operations.

(8) **Control by fungous diseases.**—A great deal of work has been done of late years in the use of various fungous diseases as a means of controlling the chinch bug. It was early observed that the chinch bug was frequently exterminated by a disease, and the idea naturally suggested itself that this disease could be collected and disseminated at the proper time and result in quick riddance of this pest. Appropri-

ations for experimentation with this disease have been made by various States, notably Illinois, Kansas, and Wisconsin, and the value of this method of control has been thoroughly tested by trained experts. The upshot of all this work has been to show that this agency of control is not of very great value. In other words, as already pointed out, unusual chinch-bug increase and damage are characteristic only of seasons of drought, and, unfortunately for the use of the diseases mentioned, they are propagated successfully and are effective only under conditions of considerable dampness or following a wet period. The very conditions, therefore, which make the disease useful are inimical to the chinch bug and, as a rule, exterminate it without the artificial introduction of the disease germs. In fact, it seems to be pretty well established that the disease occurs very generally, doubtless attacking other insects besides the chinch bugs, and whenever the weather conditions are favorable it develops itself and accomplishes the destruction of the chinch bug without the necessity of artificial introductions. It is doubtless true that occasionally when the disease is introduced just at the beginning of a rainy spell it may take hold of the bugs a little more quickly and effect their extermination more promptly than would have been the case had no artificial infections been made. In the main, however, it is scarcely worth while to bother with or rely on the introduction of this disease. If suitable climatic conditions intervene, the disease probably will itself develop and the chinch bugs will disappear. If, on the other hand, droughty conditions prevail, the introduction of the disease will be of no service.

The immature bugs seem to be especially susceptible to the action of this disease, the mature insects being much more rarely affected by it.

Summing up the subject of preventives and remedies, it may be said that the ones of real value are the clearing of farms and adjacent lands of rubbish and deadened grass by burning, the adoption of a rotation of crops which will separate the small grains from the later-ripening crops such as corn and late-sown millet, and the adoption of the steps indicated to stop the migrating midsummer hordes.

THE HESSIAN FLY.

(*Cecidomyia destructor* Say.)

Economic importance and general characteristics.—The Hessian fly (fig. 5) is one of the principal enemies of the wheat crop, the minimum annual damage due to it being estimated at about 10 per cent of the product in the chief wheat-growing sections of this country, which indicates an annual loss of 40,000,000 bushels and over. An injury of from 50 per cent to a total failure of the crop is not infrequent in certain localities, and the resulting loss is proportionately greater.

The parent insect is a very fragile, dark-colored gnat or midge, about $\frac{1}{8}$ inch long and resembling somewhat closely a small mosquito.

As commonly observed, however, more or less hidden in the base of young wheat plants or other small grains, the insect appears either in the form of a footless maggot, or larva, or in what is known as the flaxseed state, which corresponds to the chrysalis of other insects. The injury to the plant is done altogether by the larva, which feeds on the tissues and juices and weakens and eventually destroys the plant.

Distribution.—In common with many other of our more injurious farm pests, the Hessian fly is an importation from Europe; and the evidence points very strongly to the fact of its introduction in straw brought over with the Hessian troops during the war of the Revolu-

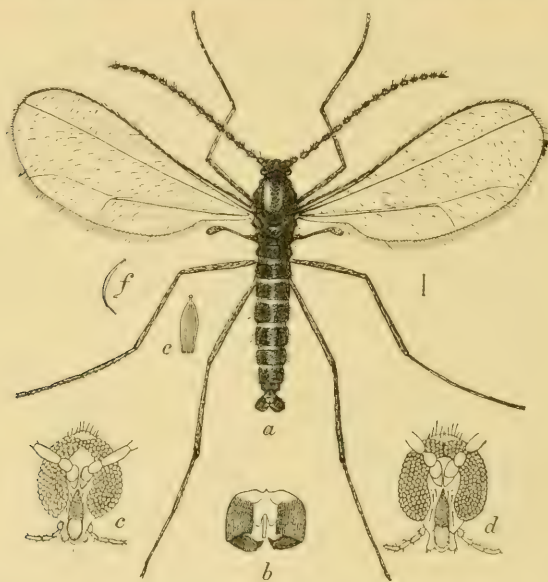


FIG. 5.—The Hessian fly (*Cecidomyia destructor*): a, male; b, enlarged anal segment of same; c, head of female; d, head of male; e, scale from leg of male; f, scale from wing; all greatly enlarged (original).

tion. It first appeared in injurious numbers in 1779 in the vicinity of the landing place of these troops three years before on Long Island, and has gradually spread westward, following the movement of settlement and wheat culture, reaching the Pacific Slope about 1884, and now practically extends throughout the wheat belt of the United States and Canada. It has long been known on the continent of Europe, covering the wheat belt from Russia westward. It appeared in England in injurious numbers in 1886 and was first thought to have been recently introduced, but has since been proved to have been present long before in barley fields. In 1888 it was reported from New Zealand and has since become an important grain pest there, thus nearly completing the circuit of the globe.

Natural history and habits.—The Hessian fly is distinctively a wheat insect, but will breed also in barley and rye. What has been taken for this insect has, in recent years, been found occasionally in timothy and several wild grasses, but the insects in these cases are now known to be distinct from the Hessian fly, and the occurrence of the latter in plants other than those first named is extremely doubtful.

Over the bulk of the wheat area of the United States there are two principal broods of the Hessian fly annually, viz, a spring and a fall brood. There are, however, supplemental broods, both in spring and in fall, particularly in the southern wheat areas, but in the extreme northern area of the spring-wheat belt there may be only a single

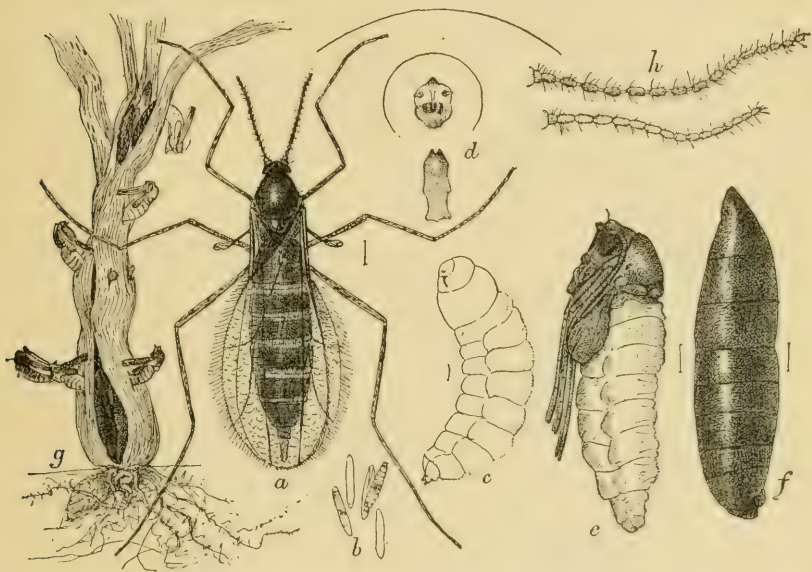


FIG. 6.—Hessian fly (*Cecidomyia destructor*): a, female fly; b, flaxseed pupa; c, larva, d, head and breastbone of same; e, puparium; f, cocoon; g, infested wheat stem showing emergence of pupæ and adults (original).

annual brood, the progeny of the spring brood passing the late summer and the winter in the flaxseed state instead of developing a brood in autumn. It is possible, however, that in this region an autumn brood may develop in volunteer spring wheat.

Each generation is represented by four distinct states, viz, (1) egg, (2) maggot, or larva, (3) pupa, or flaxseed, and (4) matured winged insect.

The eggs are very minute and slender, pale red in color, and are usually deposited in regular rows of 3 to 5 or more on the upper surface of the leaf. In the case of the spring brood they are sometimes thrust beneath the sheath of the leaf, on the lower joints. The number of eggs produced by a single female varies from 100 to 150.

The whitish maggots hatch in from three to five days and crawl down the leaf to the base of the sheath, embedding themselves between the sheath and stem, and develop on the substance of the wheat, causing more or less distortion and bulbous enlargement at the point of attack (figs. 6, 7).

In a few weeks the larva contracts into a flaxseed-like object, which is the puparium. In the case of the spring brood the insect remains in the flaxseed state during midsummer, yielding the perfect insect for the most part in September; in the case of the fall brood the winter is passed in the base of the wheat in the flaxseed condition.

The fall brood works in the young wheat very near or at the surface of the ground. The spring brood usually develops in the lower joints of the wheat, commonly so near the ground as to be left in the stubble on harvesting. With spring wheat the attack is sometimes just at the surface of the ground, as in the case of the fall brood. The adults from the wintered-over flaxseed puparia emerge during April and May, most numerous before the middle of the latter month. The adults of the important fall brood emerge chiefly during September.

There is a supplemental spring brood following the main one and a supplemental fall brood preceding the main one. These supplemental broods are, as a rule, comparatively unimportant, most of the individuals of the spring and fall broods going through the course of development first indicated. Under any favorable weather conditions, as indicated further on, the supplemental fall brood may become a very important one, as illustrated by the season of 1899-1900 in the Ohio valley.

Exceptionally also, this insect may remain dormant in the flaxseed state for a year or more and still bring forth the adult, a provision of nature which is doubtless intended to prevent the accidental extermination of the species. The migrating and scattering brood of adults is the one developed in the fall; the spring brood is less apt to scatter from the field in which it is developed.

The important feature in the life history of the Hessian fly from the standpoint of control is the time of emergence of the fall brood or



FIG. 7.—Wheat plant showing injuries by Hessian fly: *a*, egg of Hessian fly; *b*, larva; *c*, flaxseed; *d*, pupa, or chrysalis; *e*, female, natural size; *f*, female; *g*, male; *h*, flaxseed between the leaves and stalk; *i*, chalcidid parasite—all enlarged except wheat stem and fig. *c* (after Riley, Burgess, and Trounvelot).

broods of adults. This arises from the fact that the chief means of preventing loss from this insect is in sowing late enough in the fall to avoid infestation. For the average season or normal conditions dates at which sowing is comparatively safe have been determined for the principal winter-wheat districts. For example, the dates after which sowing may be safely undertaken in the State of Ohio, as shown by the very careful investigations of Professor Webster, vary over a period of at least a month from the northern latitudes of the State to the southern latitudes, or from approximately September 10, in the north, to October 10, in the south. Wheat sown after the dates mentioned, or after intervening dates for intervening latitudes, will germinate in normal seasons after the Hessian fly has disappeared and be free from attack.

The question of latitude, however, is not the only one to be considered, since temperature is affected also by altitude, and in mountainous States like West Virginia, as shown by the very careful studies of Dr. Hopkins, the altitude must be taken into consideration in determining the proper date for planting. The normal safe date for planting must be determined for each locality separately. Ohio farmers are referred to Bulletin No. 119 of the Ohio Experimental Station, by F. M. Webster, and West Virginia farmers to Bulletin No. 67 of the West Virginia Experimental Station, by A. D. Hopkins.

Unfortunately, also, it is not possible to give a uniform date for seeding which may be relied on year after year. The extraordinary development of the Hessian fly and the serious consequent losses to the crop of 1899-1900 have emphatically demonstrated this fact. The loss from the Hessian fly for the crop mentioned has been one of the worst in the history of this insect in America and probably amounted to fully 80 per cent of the normal yield throughout the infested region (fig. 8) which covered the main winter-wheat districts of the Ohio Valley and amounted to a loss of from thirty-five to forty millions of dollars worth of grain. The extraordinary multiplication of the fly for the season indicated resulted from an unusual scarcity of the parasitic enemies of the insect and a series of very favorable weather conditions, the latter, as indicated by Professor Webster, being the long drought of the autumn of 1899 which prevented the normal early hatching of the Hessian fly, and the mild autumn and winter following which enabled the insects to continue breeding and ovipositing much later than is ordinarily the case, so that few fields escaped fall infestation. A favorable winter carried these insects through safely, and the enormous number of flies which emerged for the spring brood resulted in all late-sown or other fields which had escaped the fly in autumn being infested by hordes of these insects in the spring. In other words, under the conditions of the season in question all the ordinary

rules and preventives failed absolutely and the loss of the wheat crop was almost total.

Unfortunately, similar conditions threatened the growing crop (1900-1901). The enormous abundance of the flies and a late and very mild autumn have resulted again in an extraordinary infestation by this insect over large areas.

The breeding of the Hessian fly during the autumn of 1900 continued in some localities very late. Mr. E. P. McCaslin, Seymour, Ind., who has been making very careful study and frequent reports on this insect for this office, supplies data showing that the wheat sown in that locality between October 9 and 15 was badly infested by the fly. The insect began hatching as early as the 1st of September and contin-

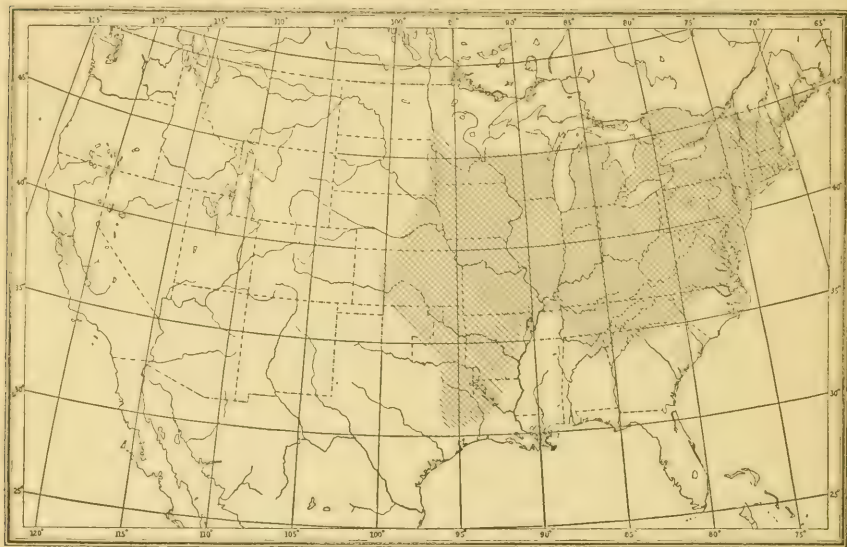


FIG. 8.—Map showing distribution of Hessian fly in America (reduced from Webster).

ued in evidence until the 1st of October, a supplemental brood appearing after October 22. The winter was so mild that undeveloped larvæ were abundant in wheat into the second week of December. A short period of zero weather in the middle of December did not destroy the larvæ (fig. 9), but a prolonged cold spell beginning about December 22 killed most of the larvæ that had not passed into the flaxseed stage. That the insect will hatch from the flaxseed stage without long hibernation if kept in a warm place was illustrated by material coming into this office which yielded flies in great numbers during January and February and deposited eggs from which young larvæ emerged.

The effect of drought on the Hessian fly was very interestingly shown by the season of 1899-1900. As pointed out by Professor Webster, a severe dry spell sufficient to prevent the germination of wheat,

such as was experienced in the Ohio Valley in the fall of 1899, will retard the development of the Hessian fly; but a week or ten days after a drenching rain, following such a dry spell, flies will come forth from the flaxseed stage in numbers. All of these conditions, therefore, must be borne in mind in attempting to determine when it is safe to sow winter wheat, and when the conditions are very unfavorable it will probably be wiser to plant other crops than those which the Hessian fly infests, as indicated in the consideration of preventives and remedies.

Effect on wheat.—The first indication in the fall of the presence of the fly in wheat is the much darker color of the leaves and the tendency to stool out rather freely. This is very noticeable, and gives the wheat for the time being a very healthy appearance. The leaves are also broader, but the upright central stems are wanting, having been killed by the fly. Later, the infested plants turn yellow or brown and die in part or altogether.

The spring brood of larvæ attacks tillers or laterals that have escaped the fall broods, dwarfing the stems and weakening them so that they usually fall before ripening and can not be successfully harvested.

The excessive stooling, or tillering, of wheat attacked by the fly is doubtless due to the natural tendency on the part of the plant to offset the injury by forming new lateral stems, and therefore a wheat that has a natural tendency in this direction is less apt to be seriously damaged by the fly. Other things being equal, also, wheat with stiff, flinty stems is less damaged by fly attack, chiefly because the straw does not bend or break so readily at the point weakened by the spring brood of larvæ.

Natural enemies.—The Hessian fly in the larval and pupal periods is subject to the attacks of important natural parasites—small four-winged flies which develop within the bodies of their hosts. There are several native parasites, and in Europe there are many others, one of which is remarkably prolific, and the Department has attempted its artificial introduction into this country. This species, *Entedon epigonus*, has been liberated in several States, and seems to have obtained a foothold, and considerable good may be expected from it.

In general, the parasites are effective only in limiting damage and are useful where other preventives are neglected, but can never take the place of active measures where perfect immunity is desired.

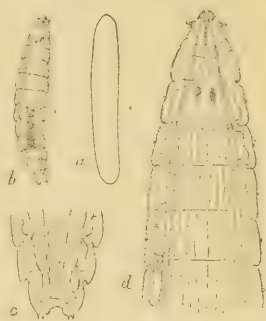


FIG. 9.—Hessian fly (*Cecidomyia destructor*): a, egg; b, larva newly hatched; c, anal segments of same; d, anterior segments of same; a, b, enlarged; c, d, greatly enlarged original.

PREVENTIVE AND REMEDIAL MEASURES.

It is practically impossible to save a field once severely attacked by this fly, and under such circumstances it is better to plow the wheat under deeply and plant to corn or other spring crop.

In cases of mild infestation the best procedure is the prompt use of fertilizers, which may enable the wheat to tiller sufficiently to yield a partial crop. Pasturing in fall of early-sown fields is also recommended, and may do some good by reducing the numbers of the pests.

Somewhat in line with pasturing of early-sown fields is an interesting experiment made in the spring of 1900 by Mr. E. P. McCaslin. Finding that the flies were ovipositing abundantly on wheat which had reached a height of 6 or 8 inches, he conceived the idea of cutting it off closely with a mowing machine as soon as all the eggs of a spring brood had been deposited, keeping close watch to determine the proper moment. The theory was that the severed tops of the wheat with attached eggs would dry up in a day or two, and the larvæ, not being able to move freely except down the green leaf blades, would fail to reach the live stubble. Wheat so cut threw out new stalks and gave every promise of a good yield, but, unfortunately for the success of the experiment, the fly was so extraordinarily abundant everywhere in the spring of 1900 that the stubble was reinfested and the experiment came to naught. Nevertheless, under a less extraordinary instance of general fly infestation, some benefit might reasonably be expected from the procedure, and it is perhaps worthy of further trial.

By some such means as the above a crop of wheat may be partly saved, but in the main the measures of really practical value against this insect are, of necessity, chiefly in the direction of preventing future injury. These are all in the line of farm methods of control, and are arranged in the order of importance as follows:

Late planting of winter wheat.—As already indicated in the paragraphs on habits and life history, late planting of winter wheat is undoubtedly the best and most practical means in normal seasons of preventing damage in regions where infestation is to be anticipated, and this is true in spite of the failure of this means of control during the season of 1899-1900. The most that can be advised under this head, however, is to give a general statement covering normal years and climatic conditions. The actual date after which planting may be safely made must necessarily be fixed for each locality separately, and be subject to yearly modification to meet varying seasonal conditions. In a general way, to avoid fly injury, planting should be made in the northern winter-wheat districts after the 15th or 20th of September, and in the more southern districts between October 1 and 15. If the right time be selected, neither early enough to be attacked by the

fly nor yet so late as to cause danger of winter killing, much of the damage in normal seasons to winter wheat from this insect may be avoided.

Burning stubble.—The fact has been noted in the life history that the second brood develops in the lower joints of the wheat and is left, for the most part, in the field in the flaxseed state at harvesting. All these individuals may be destroyed by promptly burning the stubble. Burning may be more easily effected if a rather long stubble be left, and especially if it be broken down by rolling. If the burning of the stubble be neglected until the rank growth of weeds has sprung up which usually follows harvest, it will be well to run a mower over the fields, cutting off the stubble, weeds, and grass as close to the ground as possible, and burning over as soon as the weeds and grass dry sufficiently. Careful burning will very largely prevent an abundant fall brood of flies, and may be supplemented by burning all screenings of the wheat if thrashing precedes the fall appearance of the fly.

Plowing under stubble.—In line with burning, and of nearly equal importance, is turning the stubble under by deep plowing, and afterwards rolling the field to compact the earth and prevent any flies which may mature from issuing.

Rotation of crops.—The regular practice of a system of rotation in the growth of crops is of the utmost importance in avoiding damage. Its value may be offset at times by invasion from neighboring fields of wheat on other farms, but usually comparative freedom from attack will result and the benefit will extend to the other crops coming in the system adopted in checking the insect enemies of these at the same time.

In seasons like that of 1899–1900, and possibly also 1900–1901, where the fly is very generally present, rotation of crops may fail very largely in being protective, and it may be even necessary to abandon wheat planting for a year over an entire county or State. Undoubtedly the Hessian fly can be starved out almost completely by the abandonment of the culture for one year of the crops in which it breeds, namely, wheat, rye, and barley, and occasions will probably arise again when this course will be advisable. To gain the full benefit of such a procedure all volunteer wheat, rye, or barley must be destroyed.

Trap or decoy plantings.—One of the earliest preventives recommended and one of considerable value is the early planting of narrow strips of wheat to act as decoys to attract the flies with the object of turning the infested wheat deeply under with the plow in late fall. This procedure will greatly reduce the numbers of the pest and should give greater immunity to late-planted wheat.

Destruction of volunteer wheat.—The supplemental fall brood antedating the principal brood will come to nothing if all volunteer wheat be plowed under or destroyed within a few weeks after its appearance.

This is of especial value in the North, where spring wheat is grown, and where the brood developed on the volunteer wheat may be the principal means of carrying the insect through the winter.

Growth of resistant wheats.—As indicated in the paragraph, "Effect on wheat," the importance of selecting varieties which are less injured by the attacks of the fly will be at once apparent. Such wheats are those having coarse, strong stems, and varieties which "tiller" freely or develop numerous secondary shoots. Among such wheats are the Underhill, Mediterranean, Red Cap, Red May, Clawson, etc. No wheats are, however, absolutely "fly proof."

THE WHEAT MIDGE.

(*Diplosis tritici* Kirby.)

The wheat midge (fig. 10) is another dipterous enemy of wheat, allied to the Hessian fly and the wheat bulb-worm by belonging to the same order of insects, but is entirely distinct in appearance and habit. It



FIG. 10.—Wheat midge (*Diplosis tritici*): a, female fly; b, male fly; c, larva, ventral view—all enlarged (original).

is believed to be identical with the notorious wheat midge of England and the Continent of Europe, and might easily have been brought to this country, as was probably the case, with straw, as was the Hessian fly, or in soil from infested districts. According to Fitch, it was probably first introduced into the Province of Quebec and passed down through the New England States into New York, and has thence spread westward throughout the Mississippi Valley. The adult insect is a very minute gnat or midge, not exceeding one-tenth of an inch in length, and varying in color from orange to yellow, but tarnished or slightly smoky-tinged on the back above the wings.

Injury by larvæ.—The injury occasioned by this insect to wheat and allied grains is by its orange-yellow larvæ or maggots to the forming embryos in the wheat heads. The milky juice is extracted by these

larvæ from the young kernels without any apparent gnawing of the surface, causing the grain to shrivel and the heads to blight and be imperfectly filled. On occasions of unusual outbreaks of this insect the crop is sometimes completely ruined, and occasionally the losses over whole States have averaged from two-thirds to three-fourths of the entire yield, or amounting to many millions of dollars. Damage to this extent is, however, unusual, and the wheat midge, while ranking as one of the chief insect enemies of the wheat crop, is commonly much less dreaded than the Hessian fly or the chinch bug.

The period of attack of this insect in early summer depends very much on the season, being retarded by cold and hastened by warmth. Ordinarily the fly appears about the wheat by the middle of June, and is present depositing its eggs for two or three weeks. In wet seasons it may even remain in evidence until the middle of August. Dryness is inimical to it, and unusual moisture is very favorable for its operations. It is especially active on cloudy days and at night. Wheat grown in low, moist land is therefore more subject to injury, and if unusually dry weather prevails during the period when the fly is depositing its eggs, little injury is done to the wheat crop, and, correspondingly, a wet season at the same period is liable to result in greater loss on account of this insect.

Where they oviposit.—The exceedingly minute, oval, nearly cylindrical eggs, pale red in color, are deposited singly or in clusters to the number of ten in the crevices in the wheat heads, most often at the extremity of the head, and usually in the crevices and openings which lead to the developing kernel. In about a week the eggs hatch, and the larvæ find their way at once to the kernel or germ.

Vitality of the larva.—The life of the larva is about three weeks. The full-grown larva is fairly robust, oval in shape, and has a length, when in a quiescent state, of about eight-hundredths of an inch. When in motion, it extends somewhat and tapers markedly toward the anterior extremity. It now abandons the wheat head and descends to the ground, either by skipping or jumping from the plant or crawling down the stem in a pellicle of water, being practically amphibious. Many of the larvæ are still in the wheat heads when it is harvested and are carried away from the field when the wheat is stacked. Their vitality under these circumstances, as reported by Fitch and others, is something extraordinary, as they are able to survive for months without moisture or food. Those that enter the ground in the fall form minute cocoons not larger than a mustard seed, and when covered with dirt, as they usually are, are almost impossible of discovery. It is believed that they remain unchanged in the ground until the following spring, or probably until shortly before the appearance of the adult insect again in the wheat fields in June.

PREVENTIVES.

This insect is another one of the grain pests the ravages of which are not subject to immediate remedy in the field. The only steps of importance are in the line of prevention of future injury. A practical preventive suggested by the hibernating habit of the insect is in the deep plowing of the old wheat fields to bury the larvæ so deeply in the ground that they can not escape the following year. As a further preventive, the chaff and screenings from the thrashings of wheat from an infested field should be promptly burned. The practice of rotation of crops is also applicable to this species and will be of value in proportion to the isolation of the fields or to the generality of its adoption.

THE WHEAT PLANT-LOUSE.

(*Nectarophora cerealis* Kalt.)

This plant-louse (fig. 11) is not one of the principal insect enemies of the wheat crop, but in some years, fortunately widely separated, it multiplies in enormous numbers and over wide regions, and becomes almost as destructive and occasions almost as much loss as does the Hessian fly or the chinch bug. Such periods of extensive damage were witnessed in 1861, and again in 1899. Local damage is of more frequent occurrence, and the species, in fact, occurs every year more or less, and often arouses fears which, for reasons to be subsequently explained, are not realized.

Origin.—This insect is believed to be of European origin, and is the *Siphonophora avenæ* of Riley and other authors, a common wheat pest of the Old World. There are, however, at least two other forms of plant-lice of similar habits in this country, and one of these is believed to be a native American species closely allied to the European one under consideration. The question of its origin, however, does not have much practical bearing on its present economic status in America, since it now occurs on this continent practically wherever wheat is grown. One of the other plant-lice occurring on wheat, *Nectarophora granaria* Khy., known as the grain plant-louse, is sometimes nearly or quite as bad a pest as the species under discussion. In fact, almost any plant-louse that normally attacks the various wild or cultivated grasses or even other plants may occasionally occur in wheat. The habits of these other species which may sporadically appear on wheat are substantially identical with the one under discussion, and they need not be separately considered. Even the apple-tree plant-louse, *Aphis mali*, is occasionally found in wheat fields, and this has led to an erroneous belief in some quarters that this insect and the wheat-louse are the same species and that the winter eggs of the former, which often thickly cover apple twigs, develop the spring generation of lice which appears on wheat in April. The absurdity of this point of view is

evident from the fact that the apple-tree aphid and the wheat plant-louse belong to distinct genera.

When it appears.—The wheat plant-louse appears on winter wheat in September in the form of wingless females, which rapidly reproduce themselves, going through several generations. It occurs about the base of the wheat and on the roots, remaining in evidence as late as September 30. During the fall this louse does little damage to wheat growing in good, fertile soil, and after the lice leave, the plants, as a rule, soon recover. On poor soil, however, wheat may be seriously injured at this season. The method of over-wintering has never been discovered, but it seems probable that it hibernates on the wheat in the egg stage. At any rate, the wingless female lice reappear on the wheat early in April and remain in evidence, passing again through many generations, until harvest. Throughout the spring and early summer it works on the stems and leaves above ground. Later it moves to the wheat heads, and very frequently these are simply filled with clustered masses of lice, which now assume a brownish-orange color.

Natural enemies.—Fortunately this species has many natural enemies, including various insect-feeding beetles and flies and also true internal parasites (minute four-winged flies). These predaceous enemies and parasites, in connection with other natural agencies, particularly unfavorable weather conditions, are ordinarily sufficient to prevent undue multiplication.

Cause of outbreaks.—The reasons for the periods of excessive abundance or occasional outbreaks of this insect are not always easy to point out, but as a rule such outbreaks are due to the occurrence of unusually favorable climatic conditions. A rainy and fairly cool spring and early summer are favorable to the plant-louse, because, while not checking its own multiplication to any degree, and, in fact, favoring it, the conditions described prevent its predaceous and parasitic enemies from operating to any extent. As a rule, therefore, the drier and warmer weather commonly preceding harvest enables these natural enemies to gain the upper hand and quickly exterminate the lice, and this is commonly accomplished soon enough to prevent material damage to the crop.

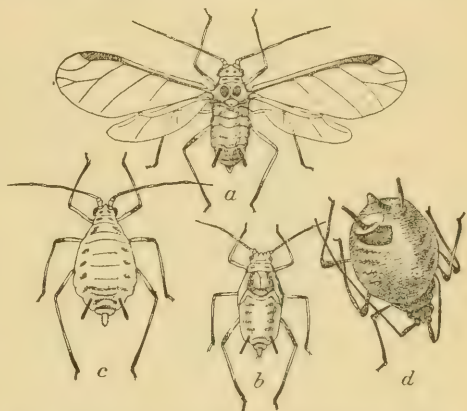


FIG. 11.—Wheat plant-louse (*Nectarophora cerealis*): a, winged migrant; b, nymph of winged migrant; c, wingless parthenogenetic female; d, wingless female, showing exit hole of parasite—all enlarged (adapted from Riley).

NO REMEDY.

No remedy is possible in case of attack by this insect, since direct application of insecticides to growing grain is out of the question, and there are no mechanical means of destroying the lice. One can only await the providence of the weather conditions and the action of natural enemies. As already pointed out, in the great majority of seasons, and often when the lice appear in the spring in numbers, unfavorable weather and the natural enemies effectually prevent appreciable damage.

THE WHEAT STRAW-WORMS.

(*Isosoma tritici* Fitch.)

(*Isosoma grande* Riley.)

The wheat stems or culms are subject to the attacks of the larvæ of certain minute insects belonging to the parasitic groups of the order

Hymenoptera, which is represented by the parasites of the Hessian fly, plant-lice, etc. This little group or subfamily to which these wheat species belong has diverged from the great mass of its allies and acquired a strictly vegetable feeding or phytophagic habit instead of subsisting parasitically on other insects. Several of these species feed on wild and cultivated grasses, and sev-



FIG. 12.—The wheat joint-worm (*Isosoma tritici*): Adult fly, much enlarged (reduced from Howard).

eral others on the various small grains. The two species which are especially destructive to wheat are known as the wheat straw-worm (*Isosoma grande* Riley) and the wheat joint worm (*Isosoma tritici* Fitch). (Fig. 12.) The habits of these two insects are similar and result in similar injuries to the wheat crop, namely, weakening the stems or culms and causing them to break and fall before the grain is ripe, and at the same time weakening the plants and decreasing the yield. (Fig. 13.)

THE WHEAT JOINT-WORM (*Isosoma tritici* Fitch).

This insect was long confused with the joint-worm of barley (*I. hordei* Harris), the habits of which it exactly duplicates. It is a true gall insect, its presence being indicated by the oblong swellings or enlargements caused by the larvæ in the walls of the wheat stems. The galls are commonly found at or near the joints, and more commonly the second joint, but may occur in the vicinity of nearly every joint on the stem.

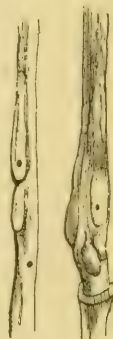


FIG. 13.—Wheat stems, showing injury by joint-worm (*Isosoma tritici*) (from Riley).

The adult insect is a minute, black, four-winged fly, measuring in length from an eighth to less than a quarter of an inch, and closely resembles in appearance its own Hymenopterous parasites and also the parasites of the Hessian fly and like insects. The galls usually occur in groups of three or four, and sometimes in large numbers together, greatly deforming and weakening the stem.

On cutting these galls open they will be found to contain when mature the joint-worm larva, yellowish white in color, with its jaws or mouth-parts tipped with brown. In the larval and pupal stages this species resembles its ally, the straw-worm, *Isosoma tritici*. This species is believed to be single-brooded, and to hibernate in its galls in the wheat stems in the larval stage, transforming to pupa and adult insect in the following spring or early summer.

THE WHEAT STRAW-WORM (*Isosoma grande*, Riley).

This insect (figs. 14, 15, 16) is very closely allied to the joint-worm. It is distinguished, however, by its habit in living free within the hol-

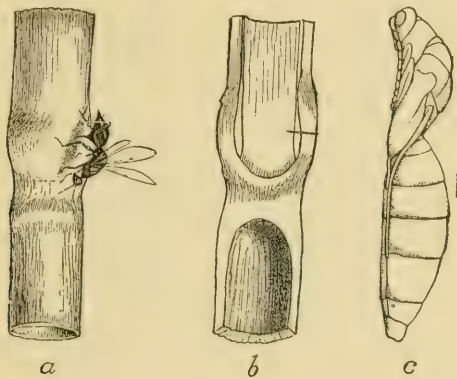


FIG. 14.—Wheat straw-worm (*Isosoma grande*); a, female inserting her eggs; b, section of wheat stem showing point reached by oviposition; c, pupa; much enlarged, c, more enlarged (after Riley).

low stems or culms of wheat, and producing no gall or deformation in the walls of the stem, as do the former species. Its work within the stem is indicated by the eaten and torn inner surface, and as a rule it does not occur in as great numbers as does the joint-worm. It winters in the stem in the pupal stage instead of the larval stage, as does the joint-worm, and is double-brooded.

Difference in appearance of the two broods.—The adults of the two broods of this insect are quite dissimilar in appearance, and have been described as distinct species. The adults, consisting of both sexes coming from the over-wintered pupæ, are rather minute, and the females are wingless or with the wings greatly aborted and functionless. The eggs of this brood are deposited about the last of April or early in May near the embryo head of the wheat, which at this season

is only a short distance above the ground. These develop and produce the adult of the second generation in June. This generation is much larger and more robust than the spring generation, and consists entirely of females provided with fully developed wings. They are therefore capable of flying readily about and constitute the migratory brood.



FIG. 15.—Wheat straw-worm (*Isosoma grande*), fall generation much enlarged (from Howard).

The eggs from this brood of large-sized females are deposited in or near the joints of the straw, more frequently near the second joint below the head. The worms on reaching maturity enter the pupal or chrysalis stage in the fall and emerge as adults the following spring.

Parasitic enemies.—Both of these insects are subject to the attacks of a number of parasitic flies which, as a rule, keep them pretty well in

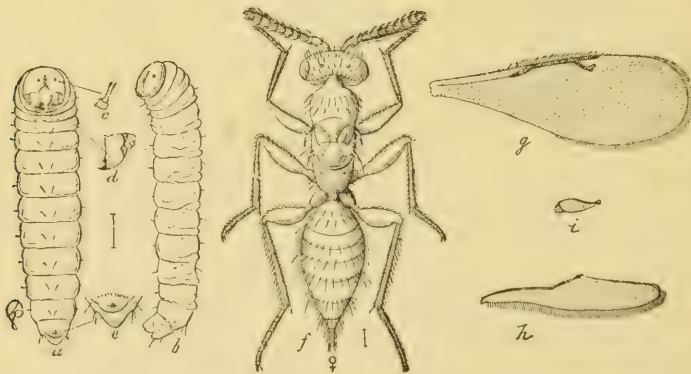


FIG. 16.—Wheat straw-worm (*Isosoma grande*), spring generation: a, b, larva; f, female; g, fore-wing; h, hind-wing; all much enlarged (from Riley).

check. The damage from the wheat straw-worms is not often of a serious nature, but is quite general, and is probably very commonly overlooked on account of the concealed habits of the larvæ, and this is especially true of the wheat straw-worm, the falling of the grain being often attributed to other causes.

REMEDY.

The remedy for both of these insects is in burning the stubble which harbors the over-wintering stages. This burning may be done either directly after harvest or at any time during fall or winter, or prior to the earliest emergence of the adults, which may begin by the latter part of March.

THE WHEAT BULB-WORM.

(*Meromyza americana* Fitch.)

The parent of the wheat bulb-worm (fig. 17) is a minute two-winged fly or gnat, not at all related to the Hessian fly, except in its habit of breeding in wheat and various grasses, and the damage due to it is doubtless very often confused with that done by the more dreaded species.

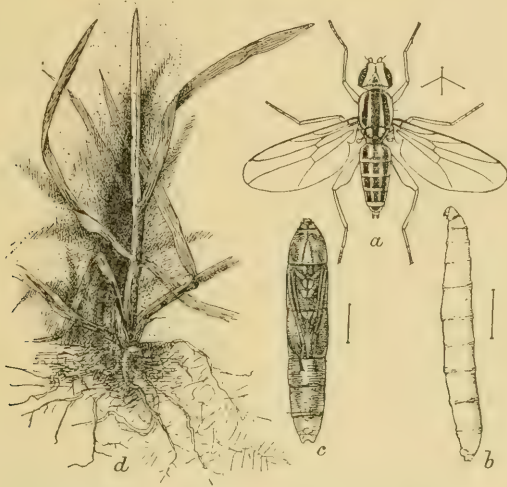


FIG. 17.—Wheat bulb-worm (*Meromyza americana*): a, mature fly; b, larva; c, puparium; d, infested wheat stem—all enlarged except d (original).

DISTRIBUTION.

The wheat bulb-worm fly is a native American species, and doubtless originally bred in various wild grasses. It is known to attack timothy and blue-stem and other grasses, and also rye, oats, and barley, as well as wheat. It is not nearly so destructive an insect as the Hessian fly, yet sometimes causes considerable loss. It is widely distributed, occurring from Canada southward to Texas, and practically covering the wheat belt of Eastern North America. It works in the wheat very much as does the Hessian fly, developing at least three generations or broods in the latitude of Ohio, and perhaps one or more additional broods in Texas and the South. The flies appear in September and October and deposit eggs (less than 0.025 of an inch in length) on the

young wheat plants. The pale watery-green footless maggots hatching from these eggs work their way down between the leaves to the crown of the plant and feed on the central part of the stem, cutting it entirely off and causing the central blade to discolor and die. These maggots pass the winter in the wheat, at the point indicated, and transform to pupæ in April and May and emerge as adults in June. An adult is about one-fifth of an inch long, greenish in color, and marked with three longitudinal black stripes on the back (thorax and abdomen). The eggs of this brood of flies are deposited, often several in a row, usually near the edge of the sheath of the upper leaf, so that the larvæ or maggots coming from them can readily penetrate the succulent portion of the stem just above the last joint, where they remain feeding on the stem and eventually killing it, causing the upper portion of the straw to wither and die and the head to blight or turn white. The second brood of adults escapes from the straw in July and August and breeds in volunteer wheat or various grasses, developing a third brood of adults in time to infest the winter wheat in September and October.

REMEDIES.

The chief remedy for the Hessian fly, namely, late planting of wheat, does not, unfortunately, apply to this closely allied pest, because the adult females of the latter are known to occur abundantly up to October. If grain can be thrashed promptly after harvest and the straw and stubble burned, it will doubtless effect the destruction of a great many of these pests, or if the grain be removed from the field as soon as practicable after being harvested most of the insects will be carried away and will not succeed in escaping from the center of the stacks at least. Rotation of crops as a preventive applies also to this insect, but even this remedy loses some of its value from the fact that the species breeds in various grasses. Fortunately, some important parasitic and predaceous insects usually keep this grain pest in check, and it is therefore unusual for it to assume a very injurious rôle, although widespread and frequently occasioning more or less loss.

THE ARMY WORMS.

(*Leucania unipuncta* Haw.)

(*Laphygma frugiperda* S. and A.)

Damage to wheat from the caterpillars commonly known as army worms and the injury caused by the allied cutworms, which come in the same category, are of such an intermittent or occasional character that the farmer can hardly be expected to take regular precautions to prevent the attacks of these insects. Severe injury is witnessed, as a rule, only at comparatively long intervals at a time in any one region, although injury probably occurs every year in some part of the coun-

try or other in varying amount. Where farms are carefully and cleanly cultivated, and not contiguous to waste or swampy land, and ground to be planted in wheat is early plowed, damage from these pests will not often be experienced.

The two worst depredators only need be discussed, namely, the army worm, *Leucania unipuncta* (figs. 18 and 19), and the grass worm, or fall army worm, *Laphygma frugiperda*.

THE ARMY WORM.

(*Leucania unipuncta* Haw.)^a

Serious army-worm outbreaks are most common in the months of May and June, or sometimes as late as July, when wheat, oats, and other small grains, corn, timothy, and various grasses, with the exception of clover, are occasionally suddenly overrun by multitudes of the dark-colored, naked, striped caterpillars of this insect. These hordes of larvae usually travel in one direction, passing from one field to another, destroying crops as they go. They have a habit, also, of climbing the stalks of such grasses as timothy and the small grains and cutting off the stems just below the head.

The army worm seems to be an indigenous North American insect, but has become widely distributed in foreign countries, and is now practically cosmopolitan. It, however, is not known to be especially injurious outside of the United States, and as an injurious farm pest its damage is practically confined to the region east of the Rocky Mountains, including Texas, and north of the tier of Gulf States.

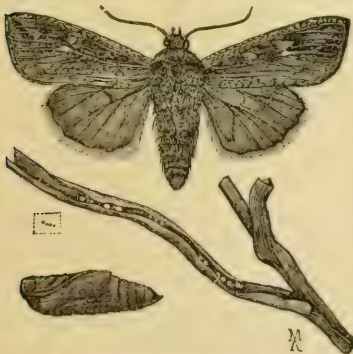


FIG. 19.—*Leucania unipuncta*, moth above, pupa below, and eggs in natural position in a grass leaf, all natural size (from Comstock).

Description.—The adult insect is a pale or yellowish-brown moth, with a white spot on the center of each fore-wing. Its minute white eggs are usually laid in numbers from two to three to twenty in strings beneath the sheaths of grass stems, a strong effort evidently being made by the female moth to conceal her litter. They are occasionally deposited also in other situations or beneath the leaf sheaths or loose bark of other plants.

The eggs hatch in from eight to ten days, and the young caterpillars feed for a time in the fold of the leaf, but grow rapidly and soon consume entire leaves.



FIG. 18.—Army worm, *Leucania unipuncta*, full-grown larva, natural size (from Comstock).

^aThis general account of the insect is condensed from Circular 4, second series, Division of Entomology, prepared by Dr. L. O. Howard.

The larvæ.—Under ordinary circumstances the larvæ feed mainly at night, or in damp, cloudy weather, remaining hidden during bright days, resembling in this habit the closely allied cutworms. They reach full growth in three or four weeks, attaining a length of $1\frac{1}{4}$ inches, burrow into the ground, and transform into brown chrysalides. In this condition they remain in the summer an average of two weeks before yielding the perfect moths.

Number of generations.—Several generations are produced each season: two or three in the Northern States and four or five or perhaps six in the Southern States.

The army worm, as a rule, passes the winter in the half-grown larval condition, occasionally in the South hibernating as a moth, and perhaps rarely in the egg stage.

This insect is present in grass land probably every year in greater or less numbers, but on account of the habit of concealment of the larva it is very rarely noted. It attracts attention and becomes a matter of grave concern only when, as a result of a series of favorable years or exceptionally favorable local conditions, it suddenly develops in enormous numbers and is forced by scarcity of food and hunger to migrate in swarms from its breeding grounds, and travels and feeds both during the day and night.

The over-wintered larvæ appearing suddenly in spring may occasionally attract notice, but as a rule the notable and destructive swarms are the progeny of the first, second, or third summer broods. In general, it may be said that these worms are more apt to make an injurious appearance in a rainy spring or early summer following a season of comparative drought. This was well illustrated in the case of the outbreaks of 1888, and especially 1894.

PREVENTIVES AND REMEDIES.

As already noted, the fact that the army worm occurs at very irregular intervals—usually widely separated, and as a rule without warning—renders it impracticable to get farmers to undertake preventive measures. In general, however, it is true that clean cultivation and the adoption of a regular system of rotation of crops in which grass lands are alternated every few years with cultivated fields will keep this insect in check and probably prevent an unusual multiplication of it. Bearing in mind also the fact that it breeds normally in rank grass and over-winters in such situations, it is of importance to burn over such tracts early every winter, which will kill many of the larvæ and leave the others to be destroyed by exposure. If these measures be practiced the army worm will probably never be able to get a migratory start, or, in fact, become abundant enough to necessitate migration.

Spraying.—The discovery of this insect is commonly made only when the advancing armies of worms have already entered valuable fields of wheat or other grain, and in case of fields so invaded nothing of a really practical nature can be done to prevent loss. Such fields may be sprinkled, by means of broadcast sprayers, with an arsenical solution, or rolled with a heavy roller when the ground is level, or pastured by a flock of sheep, which will destroy many of the worms by trampling. The arsenical application, however, will probably not save the crop, because the worms will eat enough of the crop to destroy it before they are themselves killed, and the other measures are not applicable in many cases. The main effort under such conditions should be directed toward preventing the larvæ from reaching other fields.

Distribution of poison across their line of march.—One of the best remedies available in this latter direction is the old-time one of plowing a furrow with its perpendicular side toward the field to be protected and the subsequent dragging of a log through the furrow to keep the earth friable and kill the worms which have accumulated in the ditch; another is to poison heavily with Paris green or London purple in solution a strip of pasture or field crop in advance of the traveling army of worms. In the same line is the distribution of quantities of a bran, arsenic, and sulphur-sugar mixture across their line of march. The general destruction of the worms themselves by direct applications is hardly practicable, and as a rule they can be safely left to the action of their natural parasites, which at this season are apt to be very much in evidence.

Natural enemies.—In the case, perhaps, of no other insect of equal economic importance is the action of natural enemies more effective than with the army worm, and this is especially true when its migratory instinct drives it forth from its normal protection and concealment from its natural enemies in some tuft of rank-growing grass. These enemies are species of parasitic tachina flies, rather larger than the house fly, which deposit eggs all over the bodies of the larvæ. From these eggs maggots hatch and penetrate the larva, feeding on its internal organs and eventually destroying it. One of these species, known as the red-tailed tachina fly (fig. 20), named after its host, *Nemoria leucaniæ*, may often be seen in hundreds buzzing about a field infested with the army worm, and sometimes as many as fifty of its eggs are attached to a single caterpillar. So efficient is this fly, as a rule, that on occasions of unusual increase of the army worm practically every



FIG. 20.—The red-tailed tachina fly, with its larva at left and its puparium at right; below is the forepart of the body of an army worm with tachina eggs attached, somewhat enlarged (from Comstock).

worm is parasitized, and the insect is so reduced in numbers that it does not again become abundant for a number of years, in some instances not reappearing for twelve or fourteen years. The action of this parasitic fly is assisted by various predaceous beetles, which prey upon the larvæ.

THE GRASS WORM, OR FALL ARMY WORM.

(*Laphygma frugiperda* S. & A.)

This species (fig. 21) resembles the last closely in habit, but is more distinctively southern in its range, occurring from New York and Illinois southward throughout the Southern States. The fall brood of larvæ is the one which is usually troublesome, hence its name of fall army worm. It is chiefly destructive to grasses, but occasionally raids wheat fields and destroys the young winter wheat. The half-grown larvæ in such instances suddenly appear in or migrate into the wheat fields from neighboring grass lands and feed on the wheat voraciously from the end of September until they reach full growth, some time about the 1st of October. They then enter the ground and winter in the chrysalis stage, the adults appearing in May. Like the true army worm, there are several summer broods, and in general habits and characteristics the two species are closely similar. Both the moth and the larva are extremely variable as regards colors. The moth is bluish-gray in color, with dusky wing markings, being more mottled than the army-worm moth. The larva is very dark brown in color in fall, giving the effect of an almost black insect. It is marked with a broad buff band along the sides and a narrow yellow line on the back. The under surface is greenish, more or less mottled with yellow.

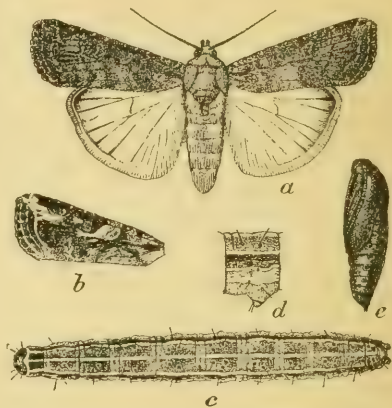


FIG. 21.—Fall army worm (*Laphygma frugiperda*): a, moth, plain gray form; b, forewing of *Prodenia*-like form; c, larva extended; d, abdominal segment of larva, lateral view; e, pupa, lateral view—d, twice natural size; others enlarged one-fourth (from Chittenden).

REMEDIES AND PRECAUTIONS.

The remedies and precautions suggested in the case of the army worm apply equally to this species, which is also probably kept in check normally by similar, and often by the same, parasitic enemies.

THE WHEAT SAWFLIES.

There are quite a number of sawfly larvæ which are occasionally found in wheat fields. Most of these have very little economic importance

and are only chance migrants to wheat from various wild grasses on which they normally feed. When seen, however, by the farmer they often arouse fears and are charged with damage with which, very likely, they have nothing to do.

The adult insects are four-winged flies, belonging to the order Hymenoptera, which includes the bees and wasps. They are termed sawflies in description of the sawlike ovipositor of the female insect with which she makes incisions in the tissues of plants for the insertion of her eggs. The larvæ of the species working on wheat either bore the stems or feed externally on the leaves. The stem-borers are the more distinctively wheat pests and are capable of doing much more damage.

STEM-BORING SAWFLIES.

Two species may be especially noted as being of possible importance in this country: First, the so-called European corn fly (*Cephus pygmaeus*) (fig. 22) and a native species (*Cephus occidentalis*) which occurs in California and works in a similar manner in the stem of a hollow grass, probably a species of *Elymus*.

The imported species, which is here better known as the European wheat sawfly, was first identified as occurring in this country about 1887 in New York^a and shortly afterwards in Canada, and was carefully studied by Professor Comstock at Cornell University. Up to the present time in this country it has never occasioned much loss. In Europe it is a well-known pest and, especially in France, is much feared.

How they pass the winter.—The adult flies appear in April and deposit eggs in the stems of the young wheat. The larvæ bore through the joints and work up and down the full length of the stem.

When full grown they attain a length of half an inch and are milky white in color. With approaching harvest they pass down to the bottom of the stem and cut the straw circularly on the inside, nearly severing it. Beneath this cut they form a little cocoon at the base of the stem, within which they pass the winter in the larval stage, transforming to pupæ and emerging as adult insects in the following summer. The object of the cut made just above their cocoon is to cause



FIG. 22.—European wheat sawfly (*Cephus pygmaeus*): a, larva; b, same enlarged; c, same in wheat stalk; d, frass; e, adult female; f, its European parasite (*Pachymerus cinctus*)—stages indicated by hair lines (reengraved from Insect Life).

^a The species was first collected in this country by Mr. F. H. Chittenden, at Ithaca, N. Y., about 1881 or 1882. (Ins. Life, Vol. IV, p. 344.)

the straw to break and allow the perfect insect to more readily escape from the stem, and the damage done by this insect is chiefly in the falling or lodging of the grain which often results from the weakening of the straw at the point indicated. Otherwise very little harm results, and the heads of attacked wheat are, as a rule, well filled.

Breeds in wheat.—This insect breeds in wheat in preference to other small grains. In fact, it is doubtful whether it often successfully develops in other grains than wheat and rye, although the females will oviposit in oats and even in the stems of grasses.

WESTERN WHEAT SAWFLY.

(*Cephus occidentalis* Marlatt.)

This insect (fig. 23) is in habit exactly similar to the European wheat sawfly, and the adult insect closely resembles the European species. Its economic importance arises from the fact that it may at any time be expected to abandon its native food plants in favor of the small grains,



FIG. 23.—Western wheat sawfly (*Cephus occidentalis*): a, larva; b, female sawfly; c, grass stem showing work—c, enlarged; a, b, more enlarged (author's illustration).

in which it can undoubtedly successfully develop. Such changes in the food habits of our native insects are being constantly witnessed, as is illustrated by several of the species already discussed and the leaf-feeding wheat sawflies, which normally affect wild grasses.

LEAF-FEEDING SAWFLIES.

As already indicated, several native American sawflies occasionally attack growing wheat. These are all species which normally feed on wild grasses. The larvæ of some half dozen species of the genus *Dolerus* have been found on wheat. The adult insects of all of these are similar, and the species *Dolerus arvensis* Say (fig. 24) may be taken as a characteristic representative of them. It is a blue-black fly, somewhat larger than the house fly, very sluggish in habit and ordinarily found in swampy places on grass in early spring. The larvæ of these

insects attain a length of nearly an inch, are usually dull or dirty whitish in color, with the head marked with brown. Some of them are also marked with brown stripes or spots along the side of the body. They occur, as a rule, singly, and are rarely in sufficient numbers to be of any economic importance.

GRASS SAWFLY (*Pachynematus extensicornis* Nort.).

A more important species is the insect bearing the scientific name of *Pachynematus extensicornis* Nort. (fig. 25), a grass sawfly about the size of a common house fly, which occurs throughout the Northern States east of the Rocky Mountains. The eggs of this insect are inserted in rows along the edge of the blades of wheat, or more commonly in grasses, and the larvæ hatching from these feed on the leaves



FIG. 24.—Leaf-feeding sawfly (*Dolerus arvensis*): female—enlarged (author's illustration).

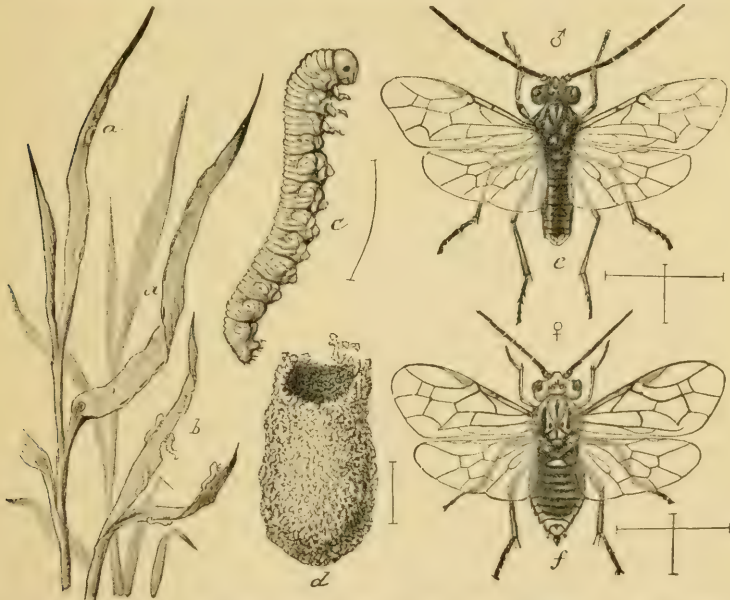


FIG. 25.—Grass sawfly (*Pachynematus extensicornis*): a, eggs in wheat blades; b, young larvæ; c, full-grown larva; d, cocoon from which adult has issued; e, male; f, female—a and b, natural size; c-f, enlarged (author's illustration).

more or less gregariously while young. As they become full grown they separate and become practically solitary feeders, as in the case of the larvæ of *Dolerus*. They may be distinguished from the latter,

however, by being uniformly yellowish green in color, with the head similarly colored, with the exception of the two minute brown eyespots, and by the possession of seven instead of eight pairs of abdominal feet.

Damage inconsiderable.—This species, also, can scarcely be considered as having great economic importance. So far as they work on the leaves of the wheat their damage is inconsiderable, but occasionally they are attracted by the green portion of the stem just below the head, especially as the wheat ripens, and sever the stalk at this point, causing considerable loss. This form of damage is more characteristic of the *Dolerus* species than of the species last described, which is more strictly a leaf feeder.

Special precautions not necessary.—The fact that damage from both the stem-boring and leaf-feeding sawflies has never been very considerable in this country has made it unnecessary to adopt any special precaution with regard to them. Where land is deeply plowed and replanted in the fall both the stem borers and the leaf feeders will be buried too deeply to escape. The only danger, therefore, comes from land that is left in stubble over winter or long enough for the adult insects to emerge in spring. Should any of these insects ever assume any especial importance, they can doubtless be kept in easy control by seeing that all wheat-stubble land is deeply turned under with the plow in the fall or winter. The likelihood of serious infestation from neighboring grass lands is not great, although not to be ignored.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to your Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 145.

CARBON BISULPHID AS AN INSECTICIDE.

BY

W. E. HINDS,

TEMPORARY ASSISTANT OF THE DIVISION OF ENTOMOLOGY.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., November 26, 1901.

SIR: While Mr. W. E. Hinds was temporarily employed as an assistant in this Division during the summer of 1901 he was instructed to conduct certain practical experiments with the use of bisulphid of carbon against the cigarette beetle (*Lasioderma serricornis*) in a large wholesale and retail tobacco establishment in the city of Washington. The successful prosecution of this work made it necessary for Mr. Hinds to familiarize himself thoroughly with the subject, and it has seemed to me very desirable that the results of his studies should be formulated in a Farmers' Bulletin for the use of persons interested in the destruction of insects injurious to stored products, underground insects, household pests, museum pests, tree borers, and sucking insects on small plants. I have, therefore, instructed him to prepare such a bulletin, and I submit his manuscript with the recommendation that it be published as a Farmers' Bulletin.

I am indebted to Mr. E. E. Ewell, of the Bureau of Chemistry, for the purely chemical portion of this bulletin, which is printed as an appendix.

Respectfully,

L. O. HOWARD,
Entomologist.

HON. JAMES WILSON,
Secretary of Agriculture.

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CARBON BISULPHID AS AN INSECTICIDE.

INTRODUCTION.

It is the purpose to bring together in the following pages some of the principal facts concerning the use and effects of carbon bisulphid. During the years since it was first used as an insecticide many important facts have been established. Records of these facts are, however, so widely scattered that it has been difficult to bring enough of them together to obtain even a fair understanding of the nature and use of this substance. Moreover, many of the most important facts have been practically buried in the mass of French literature concerning the grape Phylloxera. The writer claims but little of this work as original; but many of the conclusions he has verified by his own experiments, and the data furnished by the Bureau of Chemistry are almost wholly new. The chemical side of the subject has been treated in an appendix, in order that those desiring to do so may easily inform themselves as to the properties and behavior of the liquid which they may handle.

PROPERTIES OF CARBON BISULPHID.

Carbon bisulphid is a colorless watery liquid, formed by the union of two elementary particles of sulphur with one of carbon (charcoal). Its chemical symbol is CS_2 . It is made on a large scale by passing the fumes of burning sulphur over red-hot charcoal. The resulting vapors are condensed to a liquid form by cooling, and the impurities are removed therefrom.

LIQUID PROPERTIES.

The liquid is one-fourth heavier than water, its specific gravity being 1.29 at the freezing temperature of water. It is extremely refractive, so that when its surface is disturbed it reflects the light from the ripples much more strongly than does water. It is very volatile, evaporating with great rapidity when freely exposed to the air. The rapidity of evaporation depends mainly upon the area of the evaporating surface and the temperature of the liquid and the air. It may be retarded by mixing the liquid with various substances, and is wholly prevented by covering the surface of the carbon bisulphid with a layer of water, which, being lighter, floats easily on top just as

kerosene does upon water. The rapid evaporation of the liquid takes up a large amount of heat. If a little be poured upon the hand, a burning sensation will be experienced, which, however, is due, not to a burning, but to a cooling process, as may be perceived by touching the spot with the other hand. No harm need be feared from getting it upon the skin. When perfectly pure the liquid has an acrid taste and a rather sweetish, not unpleasant, ethereal odor, quite similar to that of ether or chloroform. Pure carbon bisulphid is completely volatile, and will not injure or stain the finest fabrics. Even when poured directly upon food stuffs their edibility is not at all impaired, and all trace of the odor disappears quickly upon free and full exposure to the air. The ordinary commercial article, however, has a slightly yellowish tinge due to its impurities, which also give it a rank fetid odor that is extremely obnoxious. These impurities add to its poisonous qualities. When the impure article is used, some slight residue may be left after the evaporation of the liquid. For this reason this grade will stain goods, and it should not be poured upon food stuffs, though its vapor will do them no harm. Liquid carbon bisulphid is not at all explosive, so there need be no fear of handling it, provided the cans are perfectly tight. It is best kept in an out-house where there is no fire and where it is dry, so that the cans will not rust and allow the vapors to escape through leaks. The liquid boils at 115° F., but a few degrees higher than the temperature of the human body. One volume of the liquid is said to give 375 volumes of vapor upon evaporation.

VAPOR PROPERTIES.

The vapor of carbon bisulphid is 2.63 times as heavy as air, and can, therefore, be poured from one glass to another almost like water. It can be seen flowing down over the edge of an open vessel containing the liquid. Although it diffuses quite rapidly through the air, as can be perceived by its odor, it is evident that the vapor will always tend to work downward more strongly than upward and that it will always be more dense at the lower levels. This point should be borne in mind, as it has an important bearing upon the application of the bisulphid. The vapor, as well as the watery solution, is a powerful disinfectant. Meats will keep in an atmosphere of it for months without change. Lamps have been devised for burning carbon bisulphid in disinfection work, but, as the active disinfectant is the same gas as is formed by burning pure sulphur or brimstone, it can be obtained more cheaply in the latter way.

EFFECTS OF INHALATION OF THE VAPOR.

Concerning the effects of the inhalation of the vapor, we learn from chemical and medical works that the gas is highly poisonous, producing giddiness, vomiting, congestion, coma, and finally death. These

of course are its extreme effects. In the ordinary use of carbon bisulphid on a large scale, as in the fumigation of mills, warehouses, etc., where the worker may be more or less exposed to the inhalation of the fumes for some time, only those effects which precede giddiness are likely to be experienced. From his own experience and information obtained from others who have used carbon bisulphid in such work, the writer gleans the following as the effects preceding giddiness: The first appreciable effect is upon the sense of smell. At first the fumes have an extremely disagreeable odor, but this soon seems gradually to disappear, showing that the sense of smell becomes deadened. The other senses seem to become benumbed simultaneously, so that the operator does not realize that anything is the matter with him. The heart beat becomes more and more rapid as the oxygen in the lungs diminishes. The power of thought is very much weakened and the work is continued in a mechanical sort of way. Hearing and sight are also weakened. But before this weakening process has gone far enough to be really dangerous or injurious, the operator will probably feel more or less dizziness. There is no pain or disagreeable sensation; no desire to get out of it, and no sense of suffocation. But when a person has reached this condition it is high time to get out into the fresh air where the ill effects will quickly disappear. Owing to the effect of the gas upon the heart action, it may be well to caution persons having any trouble or weakness about the heart against taking any extended part in the application of the bisulphid. It should be clearly understood by those who use it that the action of the gas is somewhat poisoning as well as suffocating. Should the operator persist in remaining in the room after the dizziness comes on, he will be in danger of falling, and, if not discovered, he will soon suffocate. Even if he should get out safely, the ill effects will be more marked and a severe headache, at least, may ensue. If upon the approach of dizziness, the operator goes at once to a window, or better still out of doors, an abundance of fresh air will in a few minutes remove all ill effects, and no injury will result from the experience. The inhalation of the fumes can be somewhat retarded by tying a wet handkerchief tightly over the face. This, however, merely diminishes the amount of air taken into the lungs without affecting the proportion of vapor contained therein. When obliged to enter a room in which the air is charged with any considerable amount of the vapor, the writer makes use of the following simple device, which is perfectly effectual: A large paper bag (20 quarts or more) is tied tightly around a short piece of tubing of glass, rubber, or metal, inserted in its mouth. When inflated, the bag contains sufficient air to enable one to respire into it for several minutes without discomfort. Being very light, it can be carried by the tube in the mouth, thus leaving the hands free for any work desired.

This point has been discussed rather fully, not because there is any particular danger or need for fear in handling this insecticide, but in order to lessen the fear of its use and to neutralize whatever danger there may be in its application by giving an intelligent understanding of the precise nature and effects of the chemical. When these are known, it can be handled with much greater safety and far less fear than is possible where the user knows there is danger, but does not know just what the danger is. The danger from its use is practically of the same kind as that from gasoline, which is in common use in thousands of homes. Really, the danger is very much less, since every precaution is taken to keep carbon bisulphid from the proximity of fire, while gasoline is used principally in connection with fire.

CARBON BISULPHID AS AN INSECTICIDE.

FIRST USE AS AN INSECTICIDE.

So far as the writer can learn, the first use of carbon bisulphid as an insecticide was made in 1856 and 1857 by M. Doyere, who demonstrated that a small amount of the liquid poured into a pit of corn or barley would kill all the weevils and their eggs; that this chemical agent did not alter at all the quality of the grain; that it left only a slight odor, which was not, however, persistent, but disappeared promptly upon the exposure of the grain to the free air. Since that time its use has steadily increased, and it is now generally recognized as one of the most useful insecticides.

APPLICABILITY TO VARIOUS INSECTS.

Carbon bisulphid is applicable to a large number of insect pests living under very different conditions, which, therefore, require different modes of application. These insects can be divided into groups, according to certain similarities of their habits of life or of their habitats. The members of each group have been found to be susceptible to practically the same mode of treatment with such minor variations as the individual life histories may require for greatest effectiveness. In a general way, we may say that carbon bisulphid is applicable only where its vapor can be more or less confined. Its field of usefulness is among those insects which can not be reached through poisoning their food and those that are very difficult to reach with contact insecticides by spraying. Such insects are found both indoors and out of doors, and the general methods of treatment in these two environments must necessarily vary considerably.

DIFFUSION OF THE VAPOR.

This vapor diffuses through the air very rapidly and must, therefore, be closely confined in order to maintain a sufficient proportion

of it in the atmosphere to prove fatal to insect life. It tends most strongly to spread outward and downward on account of its being so heavy, and, though it will gradually work upward, its greatest density will be at the lowest levels. The usual calculation is to employ one pound of liquid carbon bisulphid to each 1,000 cubic feet of space treated, whether for the treatment of insects in buildings or for insects in the ground. This amount gives an atmosphere, if confined to that space, composed approximately of 1 part in 90 of carbon bisulphid vapor, which, as we shall see, is a fatal strength in a short time. However, where the atmosphere can not be absolutely confined and there is considerable opportunity for the vapor to escape, it is frequently necessary to apply from two to four times that amount, under circumstances where there is no danger of killing plant life.

INSECTICIDAL POWER.

In 1876 two French investigators, Cornu and Mouillefert, performed a series of experiments to determine the insecticidal power of carbon bisulphid vapor. They were working primarily upon the grape *Phylloxera*, but, in addition to that insect, they experimented with caterpillars, butterflies, cicadas, wasps, and plant-lice. In a series of five large flasks they produced an atmosphere composed of 1 part of carbon bisulphid vapor to 12, 30, 60, 120, and 180 parts of air. Within each of these flasks grape roots bearing the *Phylloxera* were confined for twenty-four hours, at the end of which time the insects were dead in each case. In other experiments in which all of the previously mentioned insects were used it was found that in an atmosphere composed of 1 part carbon bisulphid vapor to 90 parts air, all insects perished in a few seconds, and that an atmosphere composed of 1 part of carbon bisulphid vapor to 25½ parts of air was fatal in one and one-fourth hours. The same result is therefore attained by a small proportion of the vapor acting through a long time as by a large proportion acting for a short time.

HOW PUT UP AND COST.

Carbon bisulphid is put up in tight tin cans or iron drums holding from 1 to 50 pounds. It may be purchased in small quantities of any druggist, at from 25 to 35 cents per pound; but if any considerable quantity is to be used, it is much better to buy of some wholesale druggist, or, better still, direct from the manufacturers. In the latter way it is shipped in 50 pound cans or drums at 10 cents, or even less, per pound, with an additional charge for the drums, which are returnable at the purchase price; but all freight charges are paid by the buyer.

USES OF CARBON BISULPHID.

COMMERCIAL USES.

Carbon bisulphid is extensively used in the arts as a solvent for a number of things, such as sulphur, phosphorus, oils, resins, caoutchouc, gutta-percha, etc. It is largely used in rubber manufacture, being especially valuable in the manufacture of waterproof goods. In woollen manufacture it is used to regain oils and fats from the wool. The fact of its being so widely used shows that it is not an unusually dangerous thing to handle, though there can be no doubt that the long-continued inhalation of even a little of the fumes produces very bad effects upon the health of the operators.

PHYLLOXERA TREATMENT.

It is for insects living underground especially that this insecticide fills a need which has not yet been equally well met by any other. By far its largest use in insecticidal work has been in France against the grape *Phylloxera*—a little plant-louse living mainly upon the roots of that vine. This insect is a native of the United States, and from here was introduced into France about 1859 upon imported vines. As is the rule with insect pests, this plant-louse proved to be far more destructive to the vines in France than it had been in this country. In 1863 its first injuries were manifest, and in less than ten years it had multiplied so enormously there and spread so widely that it was feared that vine growing in France was doomed. This insect's connection with the deterioration and death of the vines was not known until 1868, when it was proven by a French scientist.

This insecticide was first applied to the *Phylloxera* in 1859 by Baron Paul Thénard. Unfortunately, in attempting to force the fumes to the necessary depth to kill the insects he also killed his vines by the overdose. Later experiments gave better results. In 1873 the use of carbon bisulphid rapidly increased until over 200,000 acres were receiving annual treatment. Treatment had to be repeated for three years before the vines regained their normal condition.

This use of carbon bisulphid for the *Phylloxera* was the beginning of its underground use. The following is a summary of the principal conclusions reached by many experimenters in the course of years of work against this little root louse:

Diffusion of the vapor in the soil.—Upon being introduced into the soil at some depth below the surface the liquid evaporates as it does in the open air, only much more slowly. The vapor tends to diffuse through all the air spaces of the soil. It thus produces an atmosphere which is fatal to all insects living within its reach. The rapidity of evaporation, the extent of diffusion, and the persistence of the vapor in the soil vary widely in soils of varying characters and conditions,

so no one rule of application can be employed in all cases, and it thus becomes necessary to understand the influence of various factors that proper allowance may be made for them and the destruction of the insects attained without injuring the plants.

Moisture.—Carbon bisulphid evaporates most rapidly in a warm, dry, sandy soil, and the persistence of the vapor is also shortest in such soil. In fact it diffuses so rapidly that most insects will survive an ordinary dose; and if the dose is increased so as to kill the insects, it is likely to kill the vines as well. The treatment can not be successfully applied on such a soil in its dry condition. On the other hand, diffusion is slowest in heavy, wet, clay soil; and, when such soil is saturated with water, it is almost entirely prevented. Moisture lowers the temperature and decreases the permeability of the soil; it also prevents the evaporation of the liquid, and thus retards diffusion. Between these two extremes there is a medium condition of moisture which is most favorable for treatment.

Character of soil.—Sandy soils permit an even but too rapid diffusion of the vapor. Rocky soils are not of even texture, and naturally the vapors follow the lines of least resistance. Heavy clay soils, when very dry, are usually much broken by cracks and fissures, which may run from the surface to a considerable depth. Through such fissures the vapor escapes rapidly without permeating the soil to any extent, and its insecticidal value is therefore slight. But when such a soil is well moistened it is even in texture and very favorable to treatment.

Depth of soil.—The depth of the soil is an important factor in determining how much carbon bisulphid must be used for a given area. If the soil is shallow and the subsoil very dense and impervious, it is evident that much less liquid will be required to produce a death atmosphere than will be needed in a soil of much greater depth. In soils of the same character and condition the amount needed will be proportional to the permeable depth of the soil. In heavy, compact soils increase the number of injections and diminish the dose; in light, deep, permeable soils decrease the number of holes and increase the dose.

Amount to use.—In field experiments with the grape, using plain carbon bisulphid in "quite fresh" soil, vines were found to withstand 105 c. c. of carbon bisulphid (4.4 ounces, nearly), divided equally among 3 holes placed about 16 inches from the base of the vine and at a depth of about 20 inches; but 180 c. c. (7½ ounces) proved fatal to the vines. In a warmer, drier, more shallow soil a dose of 90 c. c. per vine, similarly placed, proved fatal. After considerable rain, when the ground was quite wet, a vine withstood 260 c. c. of carbon bisulphid, and some vines are said to have withstood 400 c. c.

Conditions favorable to treatment.—The treatment should never be applied for some time after plowing or cultivating, as a firm, compact, moist surface is much more favorable to the retention of the vapor.

For the same reason about fifteen days should be allowed after treatment before cultivation is resumed. If the soil is either very wet or very dry, treatment should be withheld. To be in the most favorable condition for treatment, the soil should be quite moist and moderately permeable, with a firm, even surface, well compacted by rain and having a depth of at least 8 inches.

Extent of diffusion.—The extent of diffusion of the vapor determines the distance apart at which the injections must be made in order to reach all parts of the soil evenly and effectively. This varies considerably with the amount of the dose, the temperature and humidity of the soil, and other conditions. It has been found more satisfactory to employ smaller and more frequent doses rather than a few large ones. A dose of 5 or 6 grams ($\frac{1}{2}$ to $\frac{1}{4}$ ounce) is believed to be thoroughly effective through a radius of from 12 to 20 inches, though it may penetrate much farther than that. The general rule is to make 3 injections per square meter ($1\frac{1}{2}$ square yards, nearly) in light soils and 4 injections in heavy soils. The arrangement of the holes must necessarily vary more or less, according to the system of planting. They should be at regular intervals, however, so as to cover the ground evenly, and never nearer than 1 foot to the base of the vine. It must be remembered that to be effective all the ground must be treated, and not merely those places where the presence of the enemy is proven by its injuries.

Repeated treatment.—On account of the liability of injuring the vines it has been found best to make the treatment in two small applications, separated by an interval of from six to ten days. This decreases the density of the vapor, but continues its action for a much longer time. It removes the danger of injuring the vines, and gives even better results upon the insects than would be obtained by one large dose. The total amount of carbon bisulphid to be used should be divided into as many equal parts as there are injections to be made. The holes for the second treatment should be intermediate between those for the first.

Depth of the holes.—The depth of the holes depends somewhat upon the depth and permeability of the soil, the average depth being about 1 foot. A depth of 16 inches is desirable upon deep or very permeable soil.

Season of application.—Treatment may be applied at any season of the year; but, as it is followed by a slight check in growth, it should not be applied either at the flowering or fruiting season, as the check would injure the crop most at those seasons. The injury to the vines results from the killing of the tender, fibrous, feeding roots. It would therefore be better to apply the treatment before these roots have started much—that is, early in spring—or after they have become hardened—that is, after fruitage in the fall. The condition of the soil usually favors the spring treatment, and the condition of the insect is

said to make it more susceptible at that time. Spring, therefore, appears to be the most favorable season.

Amount to use per acre.—Two entirely different objects may be had in treatment: First, to stamp out entirely and surely all traces of the pest upon its first appearance in a vineyard, or when desiring to reset, regardless of the life of the vines; second, to control the pest in such a way as to prevent its multiplication while continuing the culture of the vineyard. The first is called the extinction treatment; the second, cultural treatment. The method of application is the same in each case, but the amount of the dose differs. To secure extinction, it is usual to apply about 300 grams (10 ounces, nearly) per vine, using 150 grams in each of two applications ten or twelve days apart. This is said to kill ninety-nine out of every hundred vines. In cultural treatment the amount of the liquid to be used varies, according to the conditions previously described, from 140 to 265 pounds per acre.

Instruments for application.—One of the principal difficulties in the first use of carbon bisulphid was to force the vapors to the desired depth. When first used below the surface, it was poured into holes formed by driving an iron bar with a maul. The demand for a more convenient, accurate, and rapid working instrument was soon met by the invention of the pal-injector by M. Gastine. This instrument was later improved by M. Vermorel, and it fills the need admirably. The carbon bisulphid is placed in a large chamber, from which an outlet leads down through a series of valves, so adjusted that the amount of each discharge can be exactly regulated as desired, and opens near the tip of a pointed bar. The instrument is forced into the ground by the handle and the pressure of the foot upon a spur to a depth of about 1 foot; the central plunger is then pressed down and the desired amount of the liquid is discharged; the instrument is withdrawn, and the hole closed with the foot, or, as is usual in extensive work, another workman follows with a rammer, with which the holes are closed and the soil at the same time is firmly compacted. It is said that two men working together in this way can make between 2,000 and 3,000 injections per day. One acre will require on the average from 10,000 to 12,000 holes.

Plows have been invented which facilitate considerably the application, but it can not be made as deeply as with the injectors, on account of the interference of the roots. If such a plow is used, about one-fourth to one-third more of the carbon bisulphid will be required, on account of its nearness to the surface. The liquid is ejected from the machine with so much force that it becomes separated into fine drops, thus facilitating rapid evaporation. Soil is then drawn up over the liquid and compacted by the machine. Slight explosions occasionally are produced during application, especially in stony soils, by sparks caused by the steel striking against stones, but they are by no means serious.

Retarding evaporation.—Mixtures of carbon bisulphid with other substances designed to retard evaporation have been made, and the pure liquid has been used by putting it up in gelatin capsules, which allow a slow evaporation; but as these methods have not given as good results as the use of the pure liquid they will not be discussed in detail.

Many of the foregoing statements regarding the treatment of Phylloxera apply equally well to the treatment of other insects living underground.

TREATMENT FOR ROOT MAGGOTS.

Carbon bisulphid has been more or less successfully used for the cabbage root-maggot ever since 1880, when Prof. A. J. Cook experimented with it with such success that he began to recommend it. There is no doubt that its efficacy varies considerably with the nature of the soil, and there is equally little doubt that many of the failures which have been reported in its use have been due very largely to improper or too tardy application. If the liquid comes in contact with the roots, it will undoubtedly prove fatal to the plant, but a considerable amount of the vapor will do no harm. If the remedy is delayed until the plants are badly wilted, it is very likely that they will not recover, even though the enemy be killed, but their death can not fairly be attributed to the carbon bisulphid. Some growers who have tested it thoroughly state that it will work on clay or sand without injuring the plants. It has been found fatal to the pupæ as well as the larvæ. Mr. M. V. Slingerland, of the Cornell University Agricultural Experiment Station, investigated the subject in 1894¹ and his "experiments demonstrated that when properly applied the substance was sure death to the insects and did not injure the plants."

McGowen injector.—Some instrument was needed to facilitate its application, as the French pal-injectors are too heavy and too expensive. To fill this need, the McGowen injector was produced. This very convenient little instrument could be adapted to nearly all of our uses of carbon bisulphid for underground insects, but the writer has been informed by Mr. McGowen that the demand for it has been so small that he has discontinued its manufacture.

Method of application.—Whatever the instrument used, the treatment should be made in practically the same way. The hole should start 3 or 4 inches from the stem of the plant and run down obliquely to a point a little below the roots, where the liquid is deposited. The hole is then closed with earth and compacted by pressure of the foot. The dose required varies from a teaspoonful for each small plant to a tablespoonful for large plants (4 teaspoonfuls = 1 tablespoonful = 1 fluid ounce approximately). One injection will be sufficient if made in time, but if delayed too long nothing can save the plant. The conditions of

¹ See Bul. No. 78, Cornell University Experiment Station.

the soil noted under Phylloxera treatment will have practically the same influence in this case.

There appears to be no reason why a similar method of treatment may not be equally effective against such other insects as the grape root-worm (*Fidia viticida*) and the peach borer (*Sanninoidea cecitiosa*), especially on young trees, where the borer usually works just beneath the surface of the ground.

DESTRUCTION OF ANTS.

Carbon bisulphid is the best remedy known for the destruction of ants, which are frequently great nuisances to farmers and gardeners. With a little careful observation most of the common house ants, except the little red house ants, can usually be traced to their homes out of doors. The only effectual way of stopping the annoyance or injury from these insects is to destroy the queens living in the nests which they never leave.

Method of treatment.—The treatment consists in making one or more holes in the nest with a stick or iron bar to the depth of from 1 to 2 feet, and pouring into each hole 1 or 2 ounces of carbon bisulphid. The hole may be closed immediately by stepping on it; or, as many writers suggest, the vapor may be exploded at the mouth of the hole with a match, in order to drive the fumes deeper into the chambers. If the latter method is adopted, the hole should be covered with fresh earth immediately after the explosion, in order to put out the fire and confine the fumes. If this is not done, a large portion of the gas will be burned and the efficiency of the treatment be lessened thereby. Right at this point an added word of caution must be given. After the explosion the vapor continues to burn with a colorless flame. It is therefore invisible, but its presence may be easily perceived by holding the hand over the opening or by blowing into it. This point should be carefully noted, for if the operator, thinking the fire had ceased and desiring to make the extermination of the insects doubly certain, should attempt to recharge the hole from a can or bottle an explosion would surely follow, with possibly fatal results. Explosion does not appear to add to the efficacy of the treatment and is not at all necessary. If it is not attempted, it may be well to cover the nest with a wet blanket, which will aid greatly in confining the fumes. If any considerable area is infested, as is often the case in lawns, the holes should not be more than $1\frac{1}{2}$ feet apart each way, and, after the close of the application the surface treated may be thoroughly watered, as the wet surface will add to the efficiency of the treatment by preventing the rapid diffusion of the fumes into the air.

USE AGAINST WHITE GRUBS AND MOLE CRICKETS.

The same method of treatment which has just been described for use against ants infesting considerable areas in lawns will apply

equally well to the above-named insects. One ounce per square yard divided among three or four injections should give very satisfactory results. The life cycle of these insects occupies three years. The eggs are laid about June, and the young larvæ feed very close to the surface until cold weather comes on, then all go down to a considerable depth to spend the winter. The most favorable time for the treatment of these pests is after they descend in the fall and before they come up again in the spring. If treatment is made in midsummer, many of the small insects are so near the surface that they will escape, owing to the ready dilution of the vapors by the air. If the soil is fairly permeable and at least 8 inches in depth, a careful treatment should be successful and the ravages of the insects for three years will be prevented by one operation.

OTHER SUBTERRANEAN USES.

The vapor of carbon bisulphid applied at the rates previously recommended is said to have a marked action against certain cryptogamic parasites of plants, though its influence in this direction does not appear to have been much studied. It is also said to be fatal to the nematode worms, which are frequently injurious. In greenhouses these would seem to be particularly susceptible to effective treatment. The vapor of carbon bisulphid is fatal to animal life of all forms if inhaled in sufficient quantity. Within recent years this chemical has come into quite extensive and successful use against a class of small mammals which are common nuisances, if not actual pests, in many parts of the country, and particularly in the West. To Prof. E. W. Hilgard, of the University of California, is given the credit of being the first to employ this remedy against ground squirrels and gophers.¹ It is a matter of common knowledge that this agent is by far the safest and most efficient known for the destruction of prairie dogs, gophers, pocket gophers, ground squirrels, woodchucks, moles, and other pests having similar burrowing habits. The subject is quite an extensive one, and as it is now being given consideration by the Division of Biological Survey, and does not properly come within the province of the Division of Entomology, further comments here are unnecessary.

DESTROYING BORERS IN TRUNKS OF TREES.

Considerable has been written in favor of this use of carbon bisulphid. It is apparent that only the large borers which work in the trunks and lower branches of trees will be good subjects for this treatment. There are usually but few of these in each trunk, and the outlets of such burrows as contain active borers are usually marked by the sawdust and castings which the borers throw out therefrom.

¹Bul. 32, Univ. Cal., "On the Destruction of the Ground Squirrel by the use of Bisulphide of Carbon," 1878.

Only these burrows should be treated. Clean-cut empty holes in the trunk indicate that the insect has become adult and left the tree. It is, therefore, a useless waste to inject the liquid into such holes. In peach, plum, apricot, and cherry trees (all stone fruits), an abundant exudation of sap through the outlet of the burrow causes a ball of gum, mixed with castings, to collect around the hole. This should be scraped off before the treatment is applied.

Method of treatment.—Having cleaned out the mouth of the hole as well as possible, inject a small quantity of carbon bisulphid and close the hole tightly with a little grafting wax. This will quickly kill the borer and will not injure the tree; it also saves the additional injury which would necessarily be made in cutting out the borer. The saving of time alone will fully pay for the small amount of carbon bisulphid required. The liquid may be conveniently applied by means of a spring-bottomed oil can.

DESTROYING SUCKING INSECTS UPON SMALL PLANTS.

The principal pests included in this group are such insects as plant-lice, which frequently damage melon and squash vines. "The treatment, as successfully practiced by Professors Garman and Smith, consists in covering the young vines with small tight boxes, 12 to 18 inches in diameter, of either wood or paper, and introducing under each box a saucer containing one or two teaspoonfuls (1 or 2 drams) of the bisulphid. The vines of older plants may be wrapped about the hill and gathered in under larger boxes or tubs, and a greater, but proportional amount of bisulphid used. The covering should be left over the plants for three-quarters of an hour to an hour, and with 50 to 100 boxes a field may be treated with comparative rapidity."

A slight improvement upon the foregoing method of introducing the bisulphid is to bore a hole about 1 inch in diameter in the middle of the top of each box. Under this hole, inside the box, fix a small bunch of cotton waste, rags, or almost any absorbent material capable of taking up somewhat more liquid than it is intended to use; fit a stopper to the hole outside and the box is ready for use. Place it over the plant, being careful to see that the edges set into the dirt all around; remove the stopper; pour in the desired amount of liquid; replace the stopper and leave the vapor to do its work. This obviates the necessity for saucers and saves the trouble of handling more than one thing when moving from vine to vine. The carbon bisulphid might be easily carried in, and poured from, an ordinary gallon oil can such as is used for kerosene.

TREATMENT OF STORED PRODUCTS.

Agricultural products are frequently brought together in store-houses, mills, etc., in immense quantities, and, when allowed to stand

for some time, as is often the case, become particularly favorable material for the nourishment and multiplication of a large number of insect species. To exterminate these necessitates the treatment of an entire room or building.

The fumigation of buildings.—Carbon bisulphid is used in fumigating milling establishments, warehouses, storage rooms, grain elevators, stores, houses, barns, etc., for the destruction of insects affecting stored cereals and vegetable products, manufactured food products, dried tobacco and its various products, drug-store insects, and household insects which may be sufficiently numerous or injurious to warrant such treatment. Besides being efficient for the destruction of such insects, it will also kill other animals, such as rats and mice, which it may reach. The most favorable time for application may vary somewhat, as will be shown by the individual life histories of the insects treated. It would require too much space to mention all the minor details.¹

Preliminary investigation.—When a fumigation of this kind is undertaken, a preliminary investigation should be made which should make clear the nature of the pest, its habits, its injury, and as much of its life history as may be necessary to show whether one time will be more favorable to treatment than another. The building or room should be examined, its tightness ascertained, and its floor area and cubical contents computed. Objections to treatment and unavoidable dangers should be considered. In short all the pros and cons should be carefully weighed before treatment is determined upon.

Preparations for treatment.—The building should be made as tight as possible. If glass is out, it should be reset; doors and windows should be made to fit snugly, and a special examination should be made for cracks and leaks around the floors and lower walls. The place should be thoroughly swept and cleaned, and a coat of whitewash may sometimes be desirable. The material infested may be exposed, and, if movable, placed on the floors.

Shallow tin pans or plates make good evaporating dishes. The larger the evaporating area the better. There should be about 1 square foot of evaporating surface to every 25 square feet of floor area, and each square foot of evaporating surface should receive from one-half to 1 pound of the liquid. These figures are, of course, only suggestive and approximate. Pans should be placed as high in the room as possible, since the vapor is so heavy that it settles most heavily to the lower parts. Care should be taken when placing the pans to see that they are nearly level, so as to hold the liquid, though ordinarily no particular harm will be done if some of it is spilled. It should not be found necessary to lose time in adjusting such things after the application is begun. If there are special places which are difficult of

¹ See Farmers' Bulletin No. 45: Some Insects Injurious to Stored Grain.

access or treatment with the pans, cotton waste, bundles of rags, or the like may be saturated and thrown into these places. Everything should be done to avoid unnecessary delays and to facilitate the rapid exposure of the liquid. If the liquid is bought in large quantities, smaller receptacles may have to be provided for transferring it to the pans.

The exposure of the liquid.—As many men may assist in the exposure as can work to advantage. Before the cans or drums are opened the men should be cautioned as to the nature of the liquid, the danger from fire, and the necessity for rapid work. If more than one floor is to be treated, begin at the bottom and work upward. Carefully close and fasten all windows and outer doors except one through which exit is to be made when the operation is completed. Pour out the liquid as rapidly as may be done, giving each pan about its predetermined amount, and then get out quickly. Close the door and keep it locked for twenty-four hours at least, longer if possible. The best plan usually is to apply the liquid after work hours, but before dark, on Saturday evening, and leave the building closed till the following Monday morning.

Ventilation.—Doors and windows are then opened wide, at least one or two hours before it is time to resume work. The vapors disappear rapidly in the open air, and after an hour there will ordinarily be no danger in entering and but little trace of the disagreeable odor. Slight traces of the odor will probably linger in corners and places where the air does not move freely, but these gradually disappear.

Precautions.—Attention has been called to the dangers from fire in the presence of carbon-bisulphid vapor in the air, but special reference should be made to it in connection with the treatment of buildings. It is customary to mention the danger of bringing a lighted cigar or any such thing into the presence of the fumes. The application should always be made in daylight, as no artificial light of any kind is allowable. Even electric lights may not be used, since, when turning them on or off, there is always danger of producing a spark, which would prove disastrous if the vapor should be present in the proper proportion. Heated steam pipes constitute another danger to be guarded against, and they should be allowed to cool before the application is made. Electric fans must not be run, as they very frequently give off sparks. It is safer to have no heat of any kind in the building while the exposure is being made, and it is a matter of courtesy, as well as a precaution, to warn the owners of adjoining premises of the nature of the work being done, and the need for care if the vapors should penetrate to their rooms to any extent. It would be an added measure of safety to have a watchman to guard the premises from the time the application is made until ventilation is complete.

TREATMENT OF SEEDS.

Many kinds of grain and garden seeds are subject to the attack of insects. Contrary to the claims of many seedsmen, such insects do injure the germinating power of the seed. Even if the embryo itself escapes attack, which is by no means always the case, the supply of reserve food material upon which it depends wholly for its start in life is more or less consumed by the pest, and the vitality of the young plant is proportionally weakened thereby. The principal seeds attacked are corn, wheat, rice, pease, beans, and cowpeas, while vegetable seeds suffer more or less. Experiment has not yet shown any insecticide equal to carbon bisulphid for the destruction of all these seed insects.

Method of treatment.—Seeds designed for treatment with carbon bisulphid should be placed in barrels, bins, or rooms, care being taken especially to have the receptacle tight around the sides and bottom. The cubical contents of the receptacle should be computed and carbon bisulphid applied at the rate of from 1 to $1\frac{1}{2}$ pounds for each 1,000 cubic feet of space, which is the capacity of a bin or room 10 feet each way. A barrel will require a larger proportional amount unless it is very tight. The liquid is placed on top of the seed in shallow pans or soup plates, about a teacupful being placed in each. A small bin or barrel may be covered sufficiently tight with heavy blankets or oilcloth. The receptacle should be kept tightly closed from twenty-four to thirty-six hours with perfect assurance that the germinating power of the seed will not be injured. Rye, millet, barley, and crimson clover are the most liable to injury and should receive the minimum of treatment.

Fumigation houses.—In the large seed-growing districts special houses are constructed for this work. The following description of the house and the manner of treatment is given by Prof. A. J. Cook:¹

The house is made air-tight; even the door is made very close fitting, and it is made still closer by pasting paper over the edges upon closing it, after filling the house with sacks of peas. An air-tight flue at one end opens at the very top into the building and at the bottom out of doors. A sort of shoot with an adjustable air-tight valve is arranged for the turning in of the liquid. The liquid is turned in till the odor shows that the vapor is pouring out at the bottom of the flue. Then, of course, the air has been all forced out by the vapor, when the valve is closed. It is left closed for three days; then the doors are opened, that the vapor may escape, when all the weevils will be dead.

As a rule, seed pests enter the seeds in the field. Treatment is therefore most effective if made as soon as possible after harvesting.

¹In Bulletin No. 58, Michigan Agricultural Experiment Station.

TREATMENT FOR CLOTHES MOTHS.

The various insects which infest clothing, furs, etc., may be more conveniently and surely destroyed by an application of carbon bisulphid than by anything else. Moth balls, camphor, etc., may do some good by deterring the females from depositing their eggs upon articles treated therewith, but they have no killing power whatever; and if the eggs have already been deposited, the young larvæ will feed after hatching as though there were no moth balls or camphor present. Carbon bisulphid, however, will not only keep the adults away, but it will also destroy all stages of the pest infesting the goods. When woolens, furs, and the like are stored away for the summer they may be placed in a tight, paper-lined trunk, a large packing box, or some such receptacle. When all are stored away, place on top a shallow dish holding a few ounces of the liquid, spread some newspapers over the top, and cover tightly. If the box is tight, no further attention will be required; but if not, it will insure safety to repeat the dose every few weeks through the hot weather. It is an excellent plan to provide a large, tight packing chest having a close-fitting cover. Bore a hole through the cover and fasten a small sponge, bunch of cotton waste, or some such thing on the inside. The chest may then be kept tightly closed and carbon bisulphid may be poured through the hole upon the absorbent as may be necessary. Plug the hole with a cork, and all is secure. The cost of such an arrangement will very soon be saved by the convenience and security of the protection thus afforded. Carpets, rugs, robes, etc., can be easily rid of all pests by a few days' inclosure in such a box. The disagreeable odor is much less persistent in the goods than is that of moth balls or tarred paper. If pure carbon bisulphid is used it will not stain or injure the most delicate articles.

USE AGAINST OTHER HOUSEHOLD INSECTS.

Among the many insects which often abound in houses there appear to be very few which are not amenable to successful treatment in the manner already described for buildings. Cockroaches, croton bugs, bedbugs, fleas, carpet beetles, etc., can all be destroyed in tight rooms by a liberal use of the liquid. The holds of ships are frequently cleared of pests in this manner.

DESTROYING MUSEUM PESTS.

Carbon bisulphid is quite generally used for the destruction of a number of insect pests which are included under this heading. Specimens are nearly always inclosed in fairly tight showcases or trays and can be very rapidly treated by inserting the necessary amount of liquid and closing the doors or replacing the covers. In many museums a general annual treatment is given as a measure of safety, even though no enemy is known to be present.

INCIDENTAL EFFECTS OF TREATMENT WITH CARBON BISULPHID.

EFFECT OF THE VAPOR UPON PLANTS.

In using carbon bisulphid against the grape phylloxera in France, it was soon learned that direct contact of the liquid with the roots will always prove fatal to the plant, but that roots will withstand a considerable amount of the vapor without injury. The difference between the minimum of vapor which will destroy the insects and the maximum amount which can be used without injury to the plant constitutes the range of usefulness of this insecticide. Extensive experiments were made by two French investigators. Their first experiments were made by treating two series of plants, the first with varying amounts of carbon bisulphid emulsified in water, the second with the same amounts without the water. The results showed that the water moderated the action of the liquid. Succeeding experiments confirmed this result and also showed that different plants possessed different powers of resistance to the insecticide. The moderating influence of the water was doubtless due to its having increased the humidity of the soil, which, as previously stated, would retard evaporation and diffusion. Of all the plants tried, the grape appeared the most resistant. Strong, vigorous vines will also resist heavier doses than will vines enfeebled by insects or disease.

INFLUENCE UPON THE GROWTH OF CROPS.

As a general rule, the crops grown upon soil treated with carbon bisulphid are very good. This fact suggests several questions: Is the vapor itself a vegetable excitant? Does it produce chemical decompositions which render more assimilable certain nutritive elements already present in the soil? Has it some particular effect upon the humus? Or is its benefit wholly due to the destruction of the lower plant and animal organisms which, living in the soil upon the roots of the plants, steal nourishment therefrom and thus weaken the vitality of their host? None of these questions seems to have been satisfactorily answered. However, it is an acknowledged fact that the growth following treatment is unusually good, and the few records which we find indicate that the increase is considerable. Treatment of a corn-field yielded an increase of 46.8 per cent in the grain and 21.73 per cent in the stover. Potatoes showed an increase in weight varying from 5.3 per cent to 38.7 per cent. In a series of experiments upon corn, oats, beets, potatoes, and clover, much the same results were obtained, but, strange as it may seem, the most marked increase was in the clover. It was found that the vapor was not detrimental to the active bacteria causing the nodules upon the roots of this legume, but rather seemed to favor their multiplication. Furthermore, it was found upon these same plats that the beneficent influence of the treatment

was quite apparent the following year, though less marked than it had been the first year.

EFFECT UPON GERMINATION OF SEEDS.

Extensive experiments¹ were conducted by the Division of Botany, United States Department of Agriculture, upon fifty-four different varieties of seeds, including the principal grain and garden seeds affected in this way. Every precaution was taken to insure uniformity in the seeds of each lot, treated and untreated. The treated lots were exposed to an atmosphere saturated with carbon bisulphid vapor for forty-eight hours. Then these seeds and those untreated were germinated and the results tabulated. Under this extreme treatment, the severity of which would never be equaled in practice, a majority of the varieties tested showed no injury, germination being practically the same in each lot. The seeds of the grass family appeared more tender than other kinds, and some of them suffered serious damage. All varieties injured in this first treatment were then subjected to a second experiment in which they were exposed for twenty-four hours to a saturated atmosphere. Many of the varieties previously injured now showed no injury at all, and the injury was markedly decreased in all cases.

Experiments were then made upon grain in bulk, using the liquid at the rate of 1 pound to 100 bushels of grain, the rate which is usually recommended, the exposure lasting for twenty-four hours. In this case no difference could be detected in even the most delicate seeds.

EFFECT UPON FOOD STUFFS, ETC.

According to the testimony of a large number who have used this insecticide in flouring mills, food stores, and like places, the vapor has absolutely no injurious effect upon any food stuff. If the liquid is pure it can even be poured upon such articles, and after thorough exposure to the air not the slightest trace of it will remain. Of course, with impure grades, the liquid should not be poured upon such things, because the excess of sulphur and other impurities therein contained are not volatile, and upon evaporation will be left behind. It is certain that no trace of the vapor which would be absorbed by flour during an exposure thereto could persist through the processes of cooking so as to appear in the food. Owing to the extreme volatility of all the vapors given off even by the impure liquid, they will all be driven out of the flour or dough through the processes of mixing and baking. It can be positively stated that no food stuff has yet been found to be at all injured by an exposure to the vapor of carbon bisulphid.

It is believed that it would be a wise investment to give all mills,

¹Circular 11 of Division of Botany.

warehouses, and stores where grains, flour, or any food stuffs are kept a thorough annual cleaning, followed by an application of bisulphid sometime in early spring. Much if not all this insect injury would thus be avoided and the purity and cleanliness of food materials would be more fully insured.

EFFECT OF THE VAPOR UPON FRUIT.

It has already been stated that the vapor of carbon bisulphid acts as a powerful disinfectant, having the power to preserve meats unchanged for a considerable time. Very recently an Italian, M. F. Sestini, has experimented to determine its effect upon fresh fruits. The substance of his conclusions is as follows:

1. One volume of carbon bisulphid evaporated in 10,000 volumes of air produces no alteration in the character of the fruit during an exposure lasting twenty-four hours. After the treatment flavor is normal and it appears that the perfume of each fruit gains in fineness and intensity.

2. With this dose of carbon bisulphid all the common insects are easily killed in one hour.

3. Under these same conditions the color of the fruits which are not entirely sound becomes deeper, especially upon those parts of their surfaces which have suffered bruises during ripening or from defects in packing; it is thus very easy to choose carefully, rejecting such fruit as could not have been preserved.

APPENDIX.

CHEMICAL EXPERIMENTS WITH CARBON BISULPHID.

The chemical symbol of carbon bisulphid is CS_2 . Its molecules consist of one atom of carbon united with two atoms of sulphur. The specific gravity of the liquid is 1.29. The vapor is 2.63 times as heavy as atmospheric air. The pure article volatilizes rapidly and completely when exposed to the air. The liquid boils at 115°F .

The vapor takes fire in air at about 300°F . and burns with a faint blue flame, with difficulty visible in daylight, but evolving considerable heat and decomposing the carbon bisulphid into carbon dioxide (CO_2) and sulphur dioxide (SO_2). The latter is the familiar gas given off by the burning of sulphur matches and is a strongly poisonous suffocating gas, which should not be inhaled. Carbon bisulphid vapor mixed with three times its volume of oxygen, or an amount of air containing that amount of oxygen, forms a mixture which is very highly explosive upon ignition. As 21 per cent of the air is oxygen, one volume of liquid carbon bisulphid evaporated in 5,357 volumes of air would form such a mixture. An atmosphere composed of one volume of carbon bisulphid vapor to approximately 14.3 volumes of air is liable to violent explosion in the presence of fire of any kind whatever, or a temperature of about 300°F . without flame. We have here about the maximum danger point from explosion in the use of carbon bisulphid.

At the suggestion of the writer, the Division of Entomology requested information from the Bureau of Chemistry of the Department of Agriculture on the following points:

- (1) Minimum proportional volume of carbon bisulphid vapor inflammable in air.
- (2) Minimum proportional volume producing an evident explosion.
- (3) Proportion producing most violent explosion and how violent.
- (4) Maximum proportional volume giving any explosion.
- (5) Temperature of ignition point.
- (6) Relative volume of vapor given by evaporation of one volume of liquid carbon bisulphid.
- (7) The proportion of vapor of carbon bisulphid in a saturated atmosphere.
- (8) The proportion of vapor produced in 1,000 cubic feet of air by the evaporation of 1 pound of carbon bisulphid.

The following is abridged from the report prepared in response to this request in the Bureau of Chemistry by Mr. E. E. Ewell.

AMOUNT OF CARBON BISULPHID IN A SATURATED ATMOSPHERE.

Several factors affect this quantity, but the principal one is temperature. Beginning at the freezing temperature of water, 32°F ., a series of calculations was made with increments of 9°F . in temperature. As will be seen by the accompanying table, the amount of carbon bisulphid taken up increases most rapidly as the highest temperature is approached.

Amount of carbon bisulphid in a saturated atmosphere at different temperatures.

Temperature.	Pounds (avoirdupois) per 1,000 cubic feet of air.
32° F. (0° C.).....	35.8
41° F. (5° C.).....	43.9
50° F. (10° C.).....	53.5
59° F. (15° C.).....	64.6
68° F. (20° C.).....	77.6
77° F. (25° C.).....	92.4
86° F. (30° C.).....	109.3
95° F. (35° C.).....	128.6
104° F. (40° C.).....	150.4

In the following table are given the relative volumes of carbon bisulphid vapor and air in 100 volumes of an atmosphere saturated with vapor at the temperature named and at standard atmospheric pressure:

Relative volumes of CS₂ vapor and air in 100 volumes of a saturated atmosphere (reduced to standard atmospheric pressure) at various temperatures.

Temperature.	Volume of CS ₂ vapor.	Volume of air.
32° F. (0° C.).....	16.8	83.2
41° F. (5° C.).....	21.1	78.9
50° F. (10° C.).....	26.1	73.9
59° F. (15° C.).....	32.1	67.9
68° F. (20° C.).....	39.2	60.8
77° F. (25° C.).....	47.5	52.5
86° F. (30° C.).....	57.2	42.8
95° F. (35° C.).....	68.4	31.6
104° F. (40° C.).....	81.3	18.7

INFLAMMABILITY AND EXPLOSIVENESS OF CARBON BISULPHID VAPOR WITH AIR.

Three series of experiments (two with chemically pure carbon bisulphid, and one with "fuma" carbon bisulphid) were made to determine the inflammability of mixtures of carbon bisulphid (CS₂) vapor with air, and to determine the mixtures which are explosive and the violence of the explosion which takes place when these mixtures are brought in contact with a gas flame.

For the first series an atmosphere saturated with carbon bisulphid (CS₂) vapor at about 72° F. was prepared. Portions of this saturated atmosphere were transferred to graduated tubes in which it was allowed to mix with varying amounts of air. Ten tubes were prepared in this way, the percentage of the saturated air in the mixture being increased from the first to the tenth. In column 1 of the following table is given the percentage of air saturated with CS₂ vapor at 72° F. used in the mixture in each tube. In column 2 of the table the quantity of carbon bisulphid (grams per liter) in each is stated. In column 3 of the table is given a statement in regard to the degree of inflammability or explosiveness of each of the mixtures:

Inflammability of mixtures of CS₂ with the air.

Per cent of saturated air in mix- ture.	Grams* of liquid CS ₂ per liter of the mix- ture.	Inflammability.
5	0.068	Barely inflammable.
10	.135	Inflammable; very slight explosion.
20	.270	Burns with slight explosion.
30	.405	Distinctly stronger explosion.
40	.540	Slight explosion.
50	.675	Mild explosion.
60	.810	Do.
70	.945	Burns almost quietly; slight explosion.
80	1.080	Burns almost quietly; very slight explosion.
100	1.350	Burns quietly.

* One pound per 1,000 cubic feet equals 0.016 gram per liter.

It is to be noted that the explosion which occurred was not violent in any case. The strongest explosions occurred with mixtures containing from 20 to 60 volumes of air saturated with carbon bisulphid vapor at 72° F. mixed with 80 to 40 volumes, respectively, of pure air at the same temperature.

In the second series of experiments a smaller proportion of carbon bisulphid was used in three cases. Five experiments were made. The capacity of 5 bottles holding 4 liters (about 4 quarts) was obtained with approximate accuracy. For the charging of each bottle the quantity of liquid carbon bisulphid named in the following table was weighed in a small glass-stoppered weighing bottle. A string was tied to the stopper of the weighing bottle, which was then placed in the 4-liter bottle prepared to receive it. When the weighing bottle had reached the bottom of the large bottle, the stopper was removed by a sudden jerk of the string, the string was dropped in the large bottle, and it was quickly closed, the stopper being sealed in immediately with paraffin. This method of preparing the mixtures is more accurate than the one employed for the first series of experiments. The 5 bottles thus charged were allowed to stand for about three hours for the thorough diffusion of the vapor. At about the middle of this period the bottles were inverted in order to facilitate the diffusion. The stopper of each bottle was then carefully removed and a small gas jet burning at the end of a glass tube was inserted in the bottle. The results obtained are indicated in the following table:

Inflammability of mixtures of CS₂ with the air.

Bottle No.	Wt. CS ₂ per liter.	Wt. CS ₂ per 1,000 cubic feet.	Inflammability.
	<i>Grams.</i>	<i>Pounds.</i>	
1	0.0075	0.47	Not inflammable; slight odor of sulphur dioxide after removal of gas jet.
2	.0182	1.14	No general combustion; a very small blue mantle of burning carbon bisulphid formed around the gas jet.
3	.0461	2.88	No general combustion; blue mantle of burning carbon bisulphid formed around gas jet.
4	.0805	5.02	Inflammable.
5	.1552	9.68	Very inflammable; very slight explosion.

There was no general combustion except in the case of bottles Nos. 4 and 5. In the case of bottles Nos. 3 and 4 the result was very interesting. The mixture of the vapor with air was so dilute that the small gas jet introduced did not heat it hot enough to cause a general combustion, but a zone of combustion extended around the gas jet in every direction in the form of a blue mantle. It is worthy of note that the proportion of carbon bisulphid used in No. 3 (2.88 pounds per 1,000 cubic feet) is more than is ordinarily used in the fumigation of buildings. It must be remembered, however, that when small proportions of carbon bisulphid are used, the quantity in the air near the vessel containing it may be sufficient to cause an explosion if a flame is brought near it, or if the mixture be sufficiently heated by any other means.

The experiments reported above were made with chemically pure carbon bisulphid. The third series of experiments described below was made with the commercial carbon bisulphid known in the market as "fuma," which is largely used as an insecticide. As a comparison of the results will show, the inflammability of this commercial grade of carbon bisulphid is not essentially different from that of the chemically pure substance.

Inflammability of "fuma" carbon bisulphid in mixture with air.

Carbon bisulphid per liter of air.	Carbon bisulphid per 1,000 cubic feet of air.	Inflammability.
<i>Grams.</i>	<i>Pounds.</i>	
0.002	0.12	Not inflammable.
0.004	0.25	Not inflammable.
0.008	0.50	No general combustion; little or no mantle around gas jet plunged into the mixture.
0.016	1.0	No general combustion; small blue mantle of burning carbon bisulphid formed around gas jet.
0.032	2.0	No general combustion; large blue mantle formed around gas jet and in path of products of combustion.
0.051	3.18	No general combustion; large blue mantle formed around gas jet and in path of products of combustion.
0.084	5.24	Flame traveled slowly to the bottom of the bottle.
0.167	10.42	Very inflammable; scarcely explosive.
0.214	13.35	Very inflammable; distinct explosion.
0.238	14.85	Strong explosion.
0.356	22.21	Still stronger explosion.
0.468	29.20	Less strong explosion than next preceding mixture.
0.594	37.07	Less strong explosion than next preceding mixture.
0.764	47.67	Less strong explosion than next preceding mixture, but very inflammable.

IGNITION TEMPERATURE OF CARBON BISULPHID VAPOR.

The temperature at which the vapor ignites when mixed with air is given in chemical text-books as 300° F. Inasmuch as it is sometimes necessary or desirable to use the vapor in rooms in which there are steam pipes or other heating apparatus, it seemed desirable to confirm or redetermine its ignition point. In the experiments made in the Bureau of Chemistry it was found that the vapor could not be ignited at 296.6° F., but twice it took fire at 297.5° F. Of course all higher temperatures would ignite it. Chemically pure carbon bisulphid was used for these experiments.

Mr. C. E. Monroe in an address before the American Chemical Society says: "One of the most striking characteristics of the mixture which this vapor forms with air is its low point of ignition. The tiniest spark, a cinder after it has ceased to glow, or the striking together of two pieces of iron without sparking are sufficient to determine the ignition." In the open air the line of ignition appears to be quite close to that of the liquid itself as is stated by some writers and shown in some experiments by the author; but Dr. C. V. Riley once stated that the vapor ignites "at a great distance from the vessel containing it." In a closed space the ignition depends upon the presence of the vapor in proper proportions and may take place at almost any distance from the liquid. This explosive property of the mixture of the vapor with air is similar to that of alcohol, petroleum products, etc., though its ignition temperature is much lower. The flame extinguishes itself in a closed vessel which does not allow access to the air.



U. S. DEPARTMENT OF AGRICULTURE.

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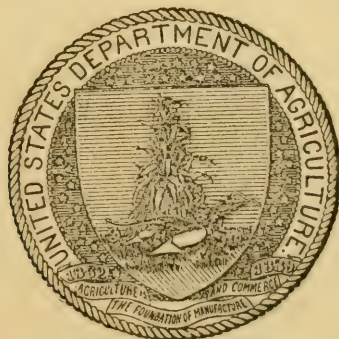
INSECTICIDES AND FUNGICIDES:

CHEMICAL COMPOSITION AND EFFECTIVENESS OF
CERTAIN PREPARATIONS.

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Bureau of Chemistry.*

Prepared under the direction of H. W. WILEY, Chief Chemist, cooperating with
the Division of Entomology.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., November 12, 1901.

SIR: The use of insecticides and fungicides has become almost indispensable to the farmer and fruit grower throughout the whole country. Immense quantities of these bodies are manufactured and placed upon the market, and without doubt the greater part of them meet the claims of the manufacturers. There are some instances, however, on record where the materials which are sold are not of sufficiently high standard to warrant their purchase, and to this extent commerce in them is to be discouraged.

This Bureau has undertaken, in connection with the Division of Entomology, a somewhat elaborate study of the insecticides found in the American markets. The object has been to obtain, if possible, samples of every kind of insecticide and fungicide offered for sale. The detailed chemical study of these bodies does not interest particularly the farmer and horticulturist, and the publication of matters of this kind, except a statement of the chemical composition of the samples examined, will be left for a more technical bulletin. There are many points, however, which have come out in the work which seem to be of great public interest and to merit publication in the form of a popular bulletin. It is with this view that the data which follow are offered to the public. There is no purpose in our work to interfere with a legitimate business, but it seems only proper that merchants, as well as purchasers, be acquainted with the real character of the goods in which they deal. It is probable that many of the manufacturers of so-called insecticides and fungicides are themselves not aware of the poor quality, sometimes almost uselessness, of the materials which they offer for sale. Information which will be beneficial both to the manufacturer and user of these articles will prove valuable.

The investigation has been confided to Mr. J. K. Haywood, who has prepared the bulletin now offered, the publication of which as a Farmers' Bulletin is respectfully recommended.

Very respectfully,

H. W. WILEY, *Chief of Bureau.*

HON. JAMES WILSON,
Secretary.



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INSECTICIDES AND FUNGICIDES: CHEMICAL COMPOSITION AND EFFECTIVENESS.

PARIS GREEN.

Among the most important insecticides now on the market is Paris green, and this article deserves first consideration. Paris green, if perfectly pure chemically, is a compound made up of three substances—arsenious acid, acetic acid, and oxide of copper—joined to each other in a chemical combination called copper aceto-arsenite. These should be present in the following proportions:

	Per cent.
Arsenious acid	58.65
Copper oxide	31.29
Acetic acid	10.06

Use of arsenious acid in free state.—Because of faulty methods of manufacture, however, and also because arsenious acid is cheaper than the other constituents of Paris green, large amounts of this substance are sometimes present in the Paris green on the market not combined as it should be with the other two constituents, but present in the free state. A sample of this kind will cause great damage to the foliage by scorching, and the avoidance of such Paris green can not be too strongly recommended. The maximum amount of free arsenious acid that should be allowed in Paris green has been found in California to be 4 per cent and in Idaho between 4 and 5 per cent.

There is no easy test by which one who is not a chemist can recognize the presence of free arsenious acid in Paris green. Intending purchasers should consult bulletins on the subject which give the names of the various manufacturers, along with an analysis showing how much of the arsenious acid is free and how much combined, as it should be with the other constituents.

Addition of calcium sulphate.—Another method of adulterating Paris green is by the addition of calcium sulphate (gypsum). It is hardly necessary to state that this substance is absolutely worthless as an insecticide and is only added to give weight. Such an adulteration as this is more rare than that first mentioned, and is also much easier of detection. To apply the test for this form of adulteration take

about as much Paris green as can be held on a 5-cent piece, transfer to a drinking glass and add about six tablespoonfuls of household ammonia; stir all the time and continue stirring for about five minutes. If the green is pure a dark blue solution will be formed and no residue will remain undissolved. If calcium sulphate is present, however, a white residue will remain suspended in the blue liquid, which will soon sink to the bottom of the glass in a compact mass.

Presence of Glauber salts.—There is one other substance that commercial samples of Paris green always contain because of their method of manufacture. This is sodium sulphate (Glauber salts). This substance will neither harm nor help plants or insects. It should not be present in good samples of Paris green except in very small amounts, 1 to 1.5 per cent, since it only adds weight and causes purchasers to pay the market price of standard goods for a weaker article.

The author has recently examined 47 samples of Paris green collected by the Division of Entomology, and finds that the total arsenious acid varies from 56.2 to 62.16 per cent, the copper oxide from 27.58 to 31.16 per cent, and the acetic acid from 6.5 to 12 per cent. Out of these 47 samples 10 had more than 1.5 per cent sodium sulphate, one reaching even to 3.59 per cent. As to free arsenious acid, there are two methods for its determination: The first, or sodium acetate extraction method, shows more nearly the amount of free arsenious acid present in the original green, while the second, or water extraction method, shows the amount of free arsenious acid originally present in the green, together with some that has been set free by the action of water on the green. Although it has not yet been proved, the second method more than likely shows more accurately the value of Paris green in actual orchard practice. By extracting with sodium acetate, one sample contained 8.91 per cent and one sample 6.37 per cent. Besides these there were 2 samples containing between 3 and 4 per cent, no samples containing between 2 and 3 per cent, and the remainder containing less than 2 per cent. By extracting with water, 19 samples contained above 5 per cent free arsenious acid, 16 between 4 and 5 per cent, and the remaining 12 below 4 per cent.

There are two other substances now being sold that are very closely allied to Paris green, and consequently will be taken up in this connection.

"GREEN ARSENOID."

The first of these is "Green Arsenoid." This compound is very much like Paris green in its composition and effect on insects. If pure, it should be composed of arsenious acid and oxide of copper joined to one another in a chemical combination called copper arsenite, but unlike Paris green it does not contain any acetic acid. An analysis

of this substance shows that besides combined arsenious acid and oxide of copper it contains—

	Per cent.
Free arsenious acid (when extracted with sodium acetate).....	3. 23
Free arsenious acid (when extracted with cold water).....	5. 88
Sodium sulphate.....	2. 02
Sand	1. 30

It will at once be seen that the percentage of free arsenious acid is somewhat too high when a water extraction is used. The amount of sodium sulphate and sand present also is too large, causing the manufacturers to gain the price of over 3 pounds of Paris green on each 100 pounds sold, with an equal loss to the consumer if the price is maintained.' We would not, of course, expect to have commercial articles entirely free of these two substances, but with care the sodium sulphate could easily be reduced to 1 per cent, and the sand to much less than 1 per cent. As a whole, however, this is a very good compound and has given excellent results in the various State stations, especially when mixed with a little lime.

"PARAGRENE."

The second substance spoken of above is a patented article "Paragrene." This is composed of arsenious acid, oxide of copper, acetic acid, and about 27 per cent gypsum. The gypsum, of course, is of no use as an insecticide, so is in the way and only adds weight. Also 6.12 per cent of the arsenious acid is present in a soluble condition. Consequently this can not be classed as a high-grade insecticide.

LONDON PURPLE.

London purple is another of the arsenical insecticides sold in America in large quantities. This substance is prepared by boiling a purple residue from the dye industry, containing free arsenious acid, with slaked lime. In this way a compound of these two substances, called calcium arsenite, is formed. This on exposure to the air during subsequent boiling is partly converted to a closely allied compound, calcium arsenate. Since the dye residue has accumulated some dirt during the process of manufacture, sand will also be present in all samples of London purple. It will thus be seen that this substance will consist of calcium arsenite, calcium arsenate, a dye residue, and small amounts of sand and moisture. In case not enough lime is added to the dye residue or the boiling is not continued long enough, some of the arsenious acid will be present in the free condition, thus causing the foliage to be scorched.

A chemical examination of four samples, recently made by the author, shows that the moisture varied from 1.87 to 4.07 per cent, the sand from 2.46 to 3.55 per cent, the arsenious acid from 6.40 to 17.31 per

cent, the arsenic acid from 26.50 to 35.62 per cent, and the calcium oxid (lime) from 23.59 to 25.09 per cent. If the arsenious acid and arsenic acid are combined and both calculated as arsenious acid, a variation of from 37.07 to 40.12 per cent only was noted. Cold water dissolved from these samples amounts of arsenious acid varying from 1.44 to 13.49 per cent and amounts of arsenic acid varying from 7.12 to 19.56 per cent.

Since calcium arsenate and calcium arsenite are both, however, somewhat soluble in water and since water breaks up both compounds to some extent on standing in contact with them, we are not able at present to say how much of this arsenic acid and arsenious acid are in the free condition and how much combined with the lime. It is probable that plants can bear without scorching larger quantities of these soluble arsenic salts than of free arsenious acid.

LEAD ARSENATE.

Lead arsenate is prepared by the action of lead acetate on sodium arsenate, and of all the arsenicals used as insecticides is probably the most insoluble and consequently the least liable to scorch the foliage. A recent analysis of a sample of "Swift's Lead Arsenate" in this laboratory showed that it contained—

	Per cent.
Lead oxide	58.90
Arsenic acid	25.62
Organic matter	13.00

The organic portion of the substance was composed almost entirely of two sugars—dextrose and dextrin—showing that glucose sirup had been added to the lead arsenate to cause it to stick to the foliage. Practical tests with this insecticide show that its action is excellent, and that on account of its almost entire insolubility it seldom scorches the foliage.

"PINK ARSENOID."

Closely allied to lead arsenate is lead arsenite sold by one firm under the name of "Pink Arsenoid" and prepared by the action of lead acetate on sodium arsenite. This substance was found by the California Experiment Station (Bulletin 126) to consist of arsenious oxide, lead oxide, small amounts of impurities, and a small amount of a pink dye stuff to color it. Only 3.24 per cent of the arsenious acid was in the free condition. This, next to lead arsenate, is probably as insoluble as any of the arsenicals, and according to reports from various experiment stations has given good results.

"WHITE ARSENOID."

Another of the arsenites—barium arsenite—was recently put on the market under the name of "White Arsenoid." This is prepared by dissolving arsenious acid in a solution of sodium carbonate and treat-

ing the resulting fluid with barium chloride. There will be formed a compound of barium oxide and arsenious acid, barium arsenite and a compound of barium oxide and carbonic acid, barium carbonate. The results from this mixture have not been good, and a chemical analysis shows that all of the arsenious acid is dissolved by cold water; so it has, it is understood, been withdrawn from the market.

"SLUG SHOT."

There is a compound called "Slug Shot" that is very extensively sold because of its cheapness. An analysis of this substance shows that it is composed almost exclusively of crude gypsum with a small amount of arsenious acid and copper oxide added, probably in the form of Paris green. The amounts of these two substances in a sample recently examined were only 1.58 per cent arsenious oxide and 0.58 per cent copper oxide. It is needless to say that an article containing as little arsenious oxide and copper as the above will do little or no good as an insecticide, while 5 cents per pound is a large price to pay for a sample consisting of nearly 100 per cent gypsum.

"BUG DEATH."

Another insecticide that has recently come into great prominence and had a very large sale all over the United States is "Bug Death." This substance is composed largely of zinc oxide with small amounts of iron oxide and lead oxide and about 3.27 per cent of ammonium and potassium chlorides. Of course the chlorides of potassium and ammonium would be of some value as plant food as far as they go.

The Sixteenth Annual Report of the Maine Agricultural Experiment Station (1900) says in regard to this insecticide:

When it is applied to potato vines at the rate of 40 pounds to the acre it has no appreciable effect on bugs, nor does it affect the foliage.

When it is applied at the rate of 100 pounds to the acre it frees the vines of bugs, but at the same time some of the leaves curl up and die.

As a fungicide this compound is of not much value, although it has a slight effect in preventing blight when applied at the rate of 180 pounds to the acre.

Finally the following remarks are made:

Because of its high cost and slow application no one growing any considerable amount of potatoes can afford to use Bug Death. The price of the labor required to apply Bug Death to 1 acre will buy the material and spray 2 acres with Bordeaux mixture and Paris green.

"BLACK DEATH."

"Black Death" is another insecticide that is now on sale in various localities. It is composed of about—

	Per cent.
Sand and charcoal.....	23.00
Gypsum and limestone	75.00
Arsenious acid	.97
Copper oxide	.59

The same statements made in regard to "Slug Shot" will apply to this mixture also.

"SMITH'S VERMIN EXTERMINATOR."

This substance, advertised to kill every species of worm, bug lice, etc., and selling at the rate of 5 cents per box, is composed of partly air-slaked lime, treated with about 3 per cent crude carbolic acid and colored with a pink dye. Even if this compound contained 50 to 60 per cent instead of 3 per cent of carbolic acid, its value as an insecticide would be extremely doubtful, but as it is, it is worthless.

LICE EXTERMINATORS.

Besides the insecticides usually spoken of in agricultural bulletins, attention is called to certain others. These are the lice killers on the market, a number of which are not worth the boxes they are put up in.

"P. D. Q."—One lice and flea exterminator analyzed in this laboratory and selling at the rate of 25 cents per box, "P. D. Q.," was found to contain about 15.5 per cent sulphur, a very small amount of some volatile substance that possessed the odor of naphthalene, and other higher coal-tar products, and 80 per cent of what appeared to be only common earth.

"Instant Louse Killer."—Another sample, selling at 25 cents per box, is "Instant Louse Killer." This consists of a very small amount of tobacco, a large amount of partially air-slaked lime treated with a small amount of the higher products of coal tar, and a large amount of what appears to be clay.

"Lambert's Death to Lice."—Still another sample, "Lambert's Death to Lice," and selling at 25 cents per box, was analyzed. It is a mixture of tobacco with a small amount of lime, which appeared to have been treated with the higher products of coal tar. Either through negligence in cleaning the tobacco or on purpose a large amount of sand is present.

It will at once be seen that all three of these lice killers are frauds. The first, it is true, does contain sulphur and a substance like naphthalene, each of which is good in driving away vermin, but it also contains 80 per cent of worthless earth for which we are paying at the rate of 20 cents per pound. The second contains nothing that will kill vermin except tobacco, and some of the higher products of coal tar, and these are present in such small quantities as to be practically of no use. The third contains enough tobacco to perhaps be of some value, but the same amount of good tobacco as in the sample could be bought for one third as much as the cost of the "Death to Lice."

ROACH DESTROYERS.

Other preparations that are very extensively sold are the roach destroyers. These usually appear in two forms, as powders and

pastes. An analysis of a number of the powders shows that nearly all of them have borax as their chief constituent. This is sometimes mixed with meal, sometimes with flour, sometimes with sugar, sometimes with Persian insect powder, sometimes with cloves, etc. The mixture is often colored with pink or blue dye stuffs. Nearly all could be prepared at home at one-half to one-tenth the cost of the store preparations. As to the pastes, all of these have from 1 to 2 per cent of phosphorous as their poisonous principle. The remainder is sometimes molasses and corn meal or flour, and sometimes glucose sirup and corn meal or flour.

BORDEAUX MIXTURE.

Probably the most important of all fungicides is Bordeaux Mixture prepared by the action of lime suspended in water on a solution of copper sulphate (blue vitriol). It has been pointed out in Farmers' Bulletin 38 of this Department that the way of mixing these two constituents has a very appreciable effect on the chemical and physical properties of the mixture. It was further pointed out that if both solutions are dilute when mixed, a product will be formed which will stay in suspension and adhere to the foliage much better than if both solutions were concentrated. There are now several firms putting up an article called "Dry Bordeaux Mixture." This article represents an attempt to supply the ready mixed Bordeaux Mixture to the consumer, but such an attempt can hardly be successful. In the first place, drying the mixture is a step farther than using concentrated fluids, so that the dry product obtained in such a way would have very different chemical characteristics from the mixture properly prepared. Again, when we dry the mixture the suspended particles become much coarser, so that when completely dry we would have a substance the principal part of which, i. e., the oxide of copper, would hardly stay in suspension at all, but would immediately sink to the bottom.

"GRAPE DUST."

"Grape Dust" is an article put up for the treatment of diseases of the grape vine. It contains—

	Per cent.
Gypsum	35.00
Sulphur	60.00
Copper oxide	.90

And 4 per cent (about) of other indifferent substances.

Two of these constituents, i. e., sulphur and oxide of copper, are of course valuable for the purpose intended, but the 35 per cent of gypsum is of no value, and only adds weight.

"VELTHA."

"Veltha," another fungicide, contains—

	Per cent.
Sand and carbon	35
Sulphate of iron (green vitriol or copperas)	65

This latter compound of course has some value as a fungicide, but the 35 per cent of sand and carbon only add weight.

"FIBRO FERRO FEEDER."

This is another substance said to be both a fungicide and a plant food. An analysis made by the Maryland Agricultural Experiment Station (The Analysis of Commercial Fertilizers, 1893) shows that it has neither nitrogen, potash, nor phosphoric acid; so of course it is of no value as a plant food. An analysis made in this laboratory shows that it consists of quite a large amount of organic matter, chloride of iron, and sulphate of iron (green vitriol) which has been partly dehydrated and partly oxidized to ferric sulphate. Although the green vitriol is of some value as a fungicide and the chloride of iron may be of use in certain cases of plant diseases, the same amount of these two ingredients as are in the Fibro Ferro Feeder could be bought for much less, and unmixed with worthless matter.

DESIRABILITY OF ASCERTAINING COMPOSITION AND VALUE OF COMPOUNDS BEFORE PURCHASING.

In view of the fact that so many of the above insecticides and fungicides are either fraudulent or extremely expensive, considering the value of the ingredients employed, it would be well for the public to be very sure of the composition and value of any such compound before purchasing. In many cases this can be done by consulting bulletins from the local experiment stations dealing with this subject. In some States the data published concerning the composition of insecticides and fungicides is extremely meager or entirely lacking. It is to supply this want that the Bureau of Chemistry has issued this bulletin, which is somewhat of a preliminary report to a bulletin more technical in character, which is in course of preparation, giving the exact chemical composition of many of these substances, bought on the open market in nearly every State of the Union.

The Bureau of Chemistry will make analyses of samples of insecticides and fungicides purchased by farmers and others using such bodies, if instructions for securing and forwarding these samples are obtained from this Bureau.

NOTES REGARDING DEPARTMENT PUBLICATIONS.

The publications of the U. S. Department of Agriculture are mainly of three general classes:

I. Publications issued annually, comprising the Yearbooks, the Annual Reports of the Department, the Annual Reports of the Bureau of Animal Industry, and the Annual Reports of the Weather Bureau.

II. Other departmental reports, divisional bulletins, etc. Of these, each Bureau, Division, and Office has its separate series, in which the publications are numbered consecutively as issued. They comprise reports and discussions of a scientific or technical character.

III. Farmers' bulletins, divisional circulars, reprinted Yearbook articles, and other popular papers.

The publications in Class I are distributed by the Department and by Senators, Representatives and Delegates in Congress. For instance, of the 500,000 copies of the Yearbook usually issued, the Department is allotted only 30,000, while the remaining 470,000 copies are distributed by Members of Congress. The Department's supply of the publications of this class is, therefore, limited, and consequently has to be reserved almost exclusively for distribution to its own special correspondents, and in return for services rendered.

The publications of Class II are not for distribution by Members of Congress, and they are not issued in editions large enough to warrant free general distribution by the Department. The supply is used mainly for distribution to those who cooperate with the Department or render it some service, and to educational and other public institutions. A sample copy of this class of publications can usually be sent on application, but, aside from this, the Department generally finds it necessary to refer applicants to the Superintendent of Documents, of whom further mention is made below.

The publications of Class III treat in a practical way of subjects of particular interest to farmers. They are usually issued in large editions, and are for free general distribution by the Department. The Farmers' Bulletins are also for distribution by Senators, Representatives and Delegates in Congress, to each of whom is furnished annually, according to law, a quota of several thousand copies for distribution among his constituents.

A limited supply of nearly all the publications in Classes I and II is, in compliance with the law, placed in the hands of the Superintendent of Documents for sale at cost of printing. Application for these should be addressed to the **Superintendent of Documents, Union Building, Washington, D. C.**, and should be accompanied by postal money order, payable to him for the amount of the price. No postage stamps or private checks should be sent. The Superintendent of Documents is not permitted to sell more than **one copy** of any public document to the same person. The Public Printer may sell to one person any number not to exceed 250 copies if ordered before the publication goes to press.

The Secretary of Agriculture has no voice in designating the public libraries which shall be depositories of public documents. Of the distribution of documents to such depositories, including the publications of this and all other Departments of the Government, the Superintendent of Documents has full charge.

For publications of the Weather Bureau, requests and remittances should be directed to the Chief of the Weather Bureau.

The Department has no list of persons to whom all publications are sent. The **Monthly List**, issued on the first day of each month, will be mailed regularly to all who apply for it. The Department also issues and sends out to all who apply for them a complete list of all publications of which the Department has a supply for free distribution, and a similar list of all the Department's publications for sale by the Superintendent of Documents.

FARMERS' BULLETINS.

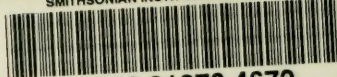
The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

16. Leguminous Plants. Pp. 24.
19. [Superseded by No. 127.]
21. Barnyard Manure. Pp. 32.
22. The Feeding of Farm Animals. Pp. 32.
23. [Superseded by No. 142.]
24. Hog Cholera and Swine Plague. Pp. 16.
25. Peanuts: Culture and Uses. Pp. 24.
26. [Superseded by No. 129.]
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds: And How to Kill Them. Pp. 32.
29. Souring and Other Changes in Milk. Pp. 23.
30. Grape Diseases on the Pacific Coast. Pp. 15.
31. Alfalfa, or Lucern. Pp. 24.
32. Silos and Silage. Pp. 32.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 29.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
37. Kafir Corn: Culture and Uses. Pp. 12.
38. Spraying for Fruit Diseases. Pp. 12.
39. Onion Culture. Pp. 31.
40. Farm Drainage. Pp. 24.
41. Fowls: Care and Feeding. Pp. 24.
42. Facts About Milk. Pp. 29.
43. Sewage Disposal on the Farm. Pp. 20.
44. Commercial Fertilizers. Pp. 24.
45. Insects Injurious to Stored Grain. Pp. 24.
46. Irrigation in Humid Climates. Pp. 27.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
50. Sorghum as a Forage Crop. Pp. 20.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
53. How to Grow Mushrooms. Pp. 20.
54. Some Common Birds. Pp. 40.
55. The Dairy Herd. Pp. 24.
56. Experiment Station Work—I. Pp. 31.
57. Butter Making on the Farm. Pp. 16.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 32.
60. Methods of Curing Tobacco. Pp. 16.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 28.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 48.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 28.
67. Forestry for Farmers. Pp. 48.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
75. The Grain Smuts. Pp. 20.
76. Tomato Growing. Pp. 39.
77. The Liming of Soils. Pp. 19.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 28.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 24.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
90. [Superseded by No. 135.]
91. Potato Diseases and Treatment. Pp. 12.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 27.
94. The Vegetable Garden. Pp. 24.
95. Good Roads for Farmers. Pp. 47.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
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114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 27.
116. Irrigation in Fruit Growing. Pp. 48.
117. Sheep, Hogs, and Horses in the Northwest. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 31.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 32.
122. Experiment Station Work—XVI. Pp. 32.
123. Red Clover Seed: Information for Purchasers. Pp. 11.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 26.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 42.
128. Eggs and Their Uses as Food. Pp. 32.
129. Sweet Potatoes. Pp. 40.
130. The Mexican Cotton Boll Weevil. Pp. 30.
131. Household Test for Detection of Oleomargarine and Renovated Butter. Pp. 11.
132. Insect Enemies of Growing Wheat. Pp. 40.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 38.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. (In press.)
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
141. Poultry Raising on the Farm. Pp. 16.
142. The Nutritive and Economic Value of Food. (In press.)
143. The Conformation of Beef and Dairy Cattle. (In press.)
144. Experiment Station Work—XIX. (In press.)
145. Carbon Bisulphid as an Insecticide. (In press.)



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